

TRANSIENT VOLTAGE PROTECTION PRODUCTS

Innovation that's proven...quality you'll recognize



PROTEK DEVICES®



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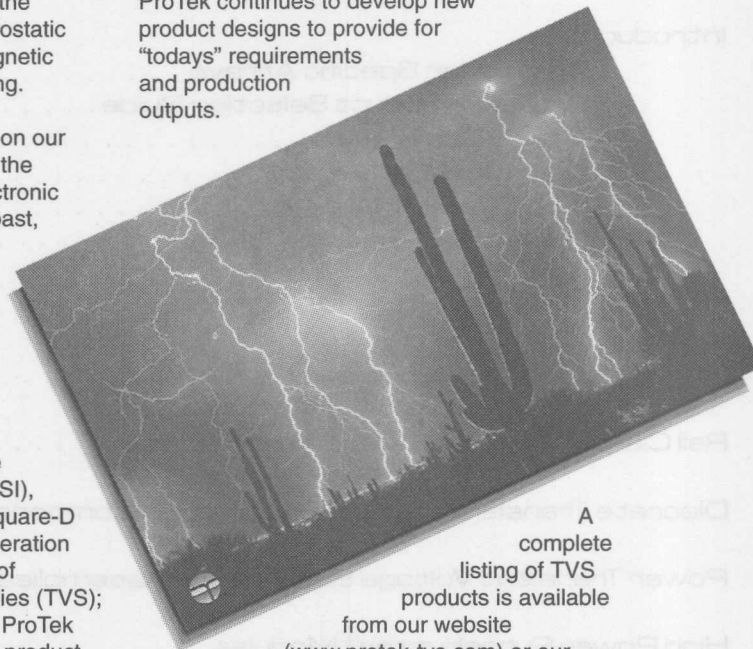
INNOVATION THAT'S PROVEN.....QUALITY YOU'LL RECOGNIZE. ProTek is a manufacturer of Transient Voltage Suppression Products that are designed specifically for the protection of electronic systems from the destructive effects of Lightning, Electrostatic Discharge (ESD), Nuclear Electromagnetic Pulse (NEMP), and Inductive Switching.

The remarkable lightning photograph on our cover, is a dramatic demonstration of the environment within which today's electronic systems must operate. In the years past, General Semiconductor Industries produced a series of catalogs using actual photographs of scenic lightning. This photo of the Arizona desert, was one of them. We are carrying on that tradition in our third edition catalog.

In 1992, ProTek Devices acquired the General Semiconductor Industries (GSI), Tempe, Arizona operation from the Square-D Company. At this time, the Tempe operation was responsible for the manufacture of transient voltage suppressor assemblies (TVS); both commercial and military. Today, ProTek manufactures a broad and diversified product line of transient voltage protection products ranging from board level, surface mount arrays to after market megawatt systems. This year we have added the rail clamp (steering diode) to our long list of products. ProTek's products are sold worldwide, both to OEM and Electronic Distributors, to a variety of markets such as telecommunications, industrial, computer, aerospace and the military.

Over the years, the engineers at ProTek have pioneered many innovative products which have become standard in the industry. ProTek engineers are active members in IEEC, NEMA, JC-13, JC-22, IEC and other industry associations, and have contributed to and played a substantial role in the formation of many of the current Standards, Specifications, and Electrical Codes for surge suppression methodology. Our engineers' extensive history,

background, and experience, has yielded an in-depth understanding of the transient environment and given ProTek the capability to manufacture world class quality devices. ProTek continues to develop new product designs to provide for "today's" requirements and production outputs.



A complete listing of TVS products is available from our website (www.protek-tvs.com) or our representatives. In addition, ProTek's experienced engineering staff is readily available to assist in providing solutions to new and/or unique customer applications.

Transient voltage protection is our only business! ProTek utilizes only the latest technologies in the design and fabrication of their products, bringing together more than 25 years of engineering and manufacturing experience to the fields of transient and surge protection. With ProTek....We've got you covered!

The cover picture is an actual photograph overlooking Tucson, Arizona using a 30 second time exposure with a 4 x 5 view camera. Ray Manley, Photographer.



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Section 1	Cross-Reference Guide (Numeric/Alpha Index)	Cross-Reference Guide
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APPLICATION SPECIFIC ARRAY FOR INDUSTRY NETWORK STANDARDS

PROTEK PART	ADSL	HDSL	T1/E1	ISDN	USB	ATM	Fast SCSI	FireWire	Ethernet
EMCxxF-LC Series								✓	✓
LCA Series	✓	✓		✓	✓	✓	✓	✓	✓
LCD Series	✓	✓		✓	✓	✓	✓	✓	✓
PLC01-6	✓	✓	✓	✓	✓				
PLC03-6	✓	✓	✓	✓					
PLCDA Series					✓	✓	✓	✓	✓
PP-SM Series	✓	✓	✓	✓					
PSLC Series					✓	✓	✓	✓	✓
PSOTxxLC Series					✓	✓	✓	✓	✓
PSRDA Series				✓	✓			✓	✓
PSRDA70-4					✓	✓	✓		
SMDAxxLCC Series					✓	✓	✓	✓	✓
SMP6LCxx-2P Series	✓	✓	✓	✓					
SM8LC Series	✓	✓		✓	✓				
SM16LC Series					✓	✓	✓	✓	✓
SM16LCxxC Series					✓	✓	✓	✓	✓
VSB06PxxLCI Series	✓	✓	✓	✓	✓	✓			
VSIP Series	✓	✓	✓	✓	✓			✓	✓



Product Selection Guide

Modules / Assemblies

High Lightning Environment &
Inductive Load Switching (Motors)

POWER

(Molded)

587B05 1/301 (AC)
587B062/302 (AC)
587B05 1LP/301LP (AC)
587B062LP/302LP (AC)
587B062LPE/302LPE
‡60KS200C/90KS (AC)
‡704-15K36/36T (DC)
‡GPZ532/1275 (DC)
PIP/‡PHP Series (AC)

DATA SIGNAL

(Molded/Board)

232E/B
420E212/260
420LE28/60LB
422E/B
422ELC
485E
485ELC
CPE 80 (Enclosure)
CX 12
CX 12LC
MB 80 (Board)
TEL50E/B
TEL185E/B

Discrete Components

Secondary Lightning &
Switching (relays, etc)

MOLDED (Plastic)

Unidirectional

15KP17/280A
15KPA17/280A
SMDJ5.0/170A

Bidirectional

15KP17C/280CA
15KPA17C/280CA
PP0640SA/PP3500SC
SMDJA5.0C/170CA

Rail Clamps/Steering Diodes

Electrostatic Discharge &
Electrically Fast Transients

MOLDED (Plastic)

Bidirectional

PMAD1103/1109
PMMAD1103/1109
PMMAD1108

Low Capacitance

PSRDA70-4

Diode Arrays

Tertiary Lightning, ESD & Switching (Logic Levels)

DUAL-IN-LINE**

Unidirectional

DA05L/M-24L/M
DA05N/P-24N/P
*DLZ-5/30A

Bidirectional

DA05CL/CM
DA05CN/CP
*DLZ-8C/30CA

Low Capacitance

LCA05C/24C
LCD05C/24C

VSIP**

Unidirectional

VS10P05 / 24
VSB10P05/24

Bidirectional

VS10P05C/24C
VSB10P05C/24C

Low Capacitance

VS10P05LC/24LC
VSB10P05LC/24LC
VS10P05LCI/24LCI
VSB10P05LCI/24LCI
VSB06P05LCI/12LCI

SURFACE MOUNT**

Unidirectional

PSMDA05-6
PSMDA05-18
PSMS05/24
PSOT03/36
PSRDA3.3-4/15-4
SMDA03/24
SMDB03/24
SM16P6K05A/58A
SM20M05-18

Bidirectional

PSM712
PSMDA05C-4/24C-4
PSMDA05C-8/24C-8
PSMS05C/24C
PSOT03/26C
SMDA03C/24C
SMDB03C/24C
SMDA05CM/24CM
SM14M05C/24C
SM16P6K05CA/58CA
SM20MT05C/24C

Low Capacitance

EMC3.3F-LC/15F-LC
PLC01-6
PLC03-6
PLCDA03/24
PSLC03/24C
PSOT03LC/24LC
SMDA03LC/24LCC
SMP6LC05-2P/12-2P
SM8LC05/24
SM16LC05/24
SM16LC05C/24C

* Denotes Hermetically Sealed Ceramic Package

** Denotes Plastic Packaging.

TYPICAL DESIGN AIDS FOR AVALANCHE BREAKDOWN TRANSIENT VOLTAGE SUPPRESSORS

- 1) Leakage current will double for every 10°C to 15°C rise in temperature depending upon the voltage (usually referenced to the ambient temperature).
- 2) The typical change in Breakdown Voltage (BV or $V_{(BR)}$) with variations in temperature is defined by the following equations:

$$BV \text{ (actual value)} - 4 = + \text{ mv/}^{\circ}\text{C (temperature coefficient)}$$

This applies to voltages greater than 6 volts. The temperature coefficient does not apply to the clamping voltage as the current derating factor takes into account any rise in voltage due to thermal effects.

- 3) The Peak Pulse Power (P_{PP}) or Peak Pulse Current (I_{PP}) rating will triple for every 1/10 (decade) decrease in impulse width.
- 4) The Peak Pulse Power (P_{PP}) is calculated by multiplying the Peak Pulse Current (I_{PP}) times the Maximum Clamping Voltage (V_C). Note the current is not coincident in time with the voltage.
- 5) For design purposes, the Maximum Clamping Voltage (V_C) is considered constant at peak pulse power ratings for the specified time duration range.
- 6) The differential Clamping Voltage ($\Delta V_C = V_C - V_{(BR)}$) is composed of two (2) components, resistive (bulk material) and thermal. For low voltage devices ($\leq 10V$), approximately 1/3 of the voltage rise is thermal. For higher voltage devices (about 200V), approximately 2/3 of the voltage rise is thermal.
- 7) The Maximum Clamping Voltage (V_C) is 1.33 times the actual Breakdown Voltage ($V_{(BR)}$) at full rated power. At half (50%) rated power the clamping factor is 1.20 times the Breakdown Voltage.
- 8) Capacitance will decrease as frequency increases. At zero bias, the rate of change is about 8%, and with a reverse bias, the rate of change can vary from 30-50%.
- 9) The Minimum Breakdown Voltage ($V_{(BR)}$) is calculated by multiplying the Stand-Off Voltage (V_{WM}) times 1.11. The Maximum Breakdown Voltage is calculated by multiplying the Minimum Breakdown Voltage by 1.1 for a typical 5% (premium) product and by 1.22 for a typical 10% (common) product.
- 10) A transient voltage suppressor is normally selected according to its Rated Stand-off Voltage (V_{WM}) which should be equal to or greater than the continuous peak operating voltage level.



DEFINITIONS

Crosstalk, Noise:

Voltage and current changing in an active line causing induced noise in an adjacent line. There are two types of crosstalk measurements, Forward Crosstalk measured at the far end of a passive line and Reverse Crosstalk measured at the near end of the line.

Electromagnetic Compatibility (EMC):

EMC today, encompasses both Radiated Emissions and Transient Immunity, reference IEC 1000-4.

Ground Bounce:

A voltage potential that exists between two connecting ground planes. This will occur when a current, either intended or a transient current, causes a voltage potential between two ground points of the same circuit system due to the inductance (impedance) in the interconnecting lead (trace).

Grounding, TVS Arrays:

A ground plane or low impedance trace on a printed circuit board (PCB), where each of the ground pins of an array package have a common connection. To maintain a low impedance return path for a transient current, connect each ground pin of the array to a ground plane, or low impedance PCB trace.

Reflections, Voltage:

An oscillatory decaying signal voltage which is produced by a mismatch in the terminating impedance. The amplitude of a voltage reflection can be two to three times higher than the incident voltage with a higher frequency content (double the switching rate). Reflections can degrade system performance by reducing noise margins, introduce propagation delays, and cause undershoot and overshoot voltages in a circuit.

Shielding, PCB:

A method of applying a ground plane to reduce EMF/RFI within a PCB. Ground planes are used over the signal line traces to reduce outside interference. This will reduce radiated emissions effects, but not the conducted emissions effect from I/O ports.

Switching, CMOS:

Results in a momentary "short circuit" for the V_{DD} to ground. This can occur during the rise or fall time of a signal, similar to a switching transistor action, creating a voltage pulse on the edge of the signal.

**IEEE DICTIONARY
(ANSI/IEEE STANDARD 100-1989)**

Impulse	A surge of unidirectional polarity.
Pulse	A brief excursion of a quantity from normal.
Risetime	The time interval of the leading edge between the instants at which the instantaneous value first reaches the specified lower and upper limits of 10% and 90% of A_M . Limits other than 10% and 90% may be specified in special cases.
Spike	A distortion in the form of a pulse waveform of relatively short duration superimposed on an otherwise regular or desired pulse waveform.
Surge	A transient wave of current, potential, or power in an electric circuit.
Surge Arrester (AC Power Circuits)	A protective device for limiting surge voltages on equipment by diverting surge current and returning the device to its original status. It is capable of repeating these functions as specified.
Surge Protector	A protective device, consisting of one or more surge arresters, a mounting assembly, optional fuses and short circuiting devices, etc., which is used for limiting surge voltage of low-voltage (1000V root-mean-square of 1200V direct current) electrical or electronic equipment or circuits.
Surge Suppressor	A Device operative in conformance with the rate of change of current, voltage, power, etc., to prevent the rise of such quantity above a predetermined value.
Transient	That part of the change in a variable that disappears during transition from one steady-state operating condition to another, such as a voltage or current.
Transient Suppression Network	Capacitors, resistors, or inductors so placed as to control the discharge of stored energy banks. They are commonly used to suppress transients caused by switching.
Wave	A variation of current, potential, or power at any point in the electrical circuit.
Waveform	A manifestation or representation (i.e., graph, plot, oscilloscope presentation, equation(s), table of coordinate or statistical data, etc.) or a visualization of a wave, pulse, or transition.
Wavefront	That part which occurs prior to the crest value.
Waveshape	The graph of the wave as a function of time.



GLOSSARY

TERM & SYMBOL

DESCRIPTION

Ambient Temperature, t_A	The ambient or room air temperature.
Breakdown Current, $I_{(BR)}$	The current through the device in the breakdown condition (region).
Breakdown Voltage, $V_{(BR)}$	The voltage measured across the device at a specified pulsed dc current (I_T or $I_{(BR)}$) on the V/I characteristic curve at or near to where the breakdown (avalanche) occurs. Also known as the voltage across the device in the breakdown region prior to the switching point at a specified breakdown current ($I_{(BR)}$).
Breakover Current, $I_{(BO)}$	The instantaneous current flowing at the Breakover Voltage ($V_{(BO)}$).
Breakover Voltage, $V_{(BO)}$	The maximum voltage across the device in or at the breakdown region measured under a specified rate of rise and current rate of rise.
Capacitance, C_j	The capacitance between two terminals of the device measured at a specific frequency and bias, also shown as C or C_O
Clamping Voltage, V_C	The peak voltage measured across the device during the application of a pulse current (I_{PP}) for a specified waveform.
Critical Rate of Rise of On-State Voltage, di/dt	The rated value of the rate of rise of current which the device can withstand without damage.
Critical Rate of Rise of On-State Current, dv/dt	The maximum rate of rise of voltage (below V_{DRM}) that will not cause switching from the off-state to the on-state.
Forward Current, I_F	The current through the device in the forward conducting state.
Forward Voltage, V_F	The voltage across the device in the forward conducting state at a specified current, I_F .
Front Time, t_f	The time for the rising edge of an impulse to reach its peak value measured from t_0 .
Holding Current, I_H	The minimum anode, principal, or thyristor current required to maintain the device in the on state.
Junction Temperature, t_j	The temperature at the junction of a P/N semiconductor chip.
Lead Temperature, t_L	The temperature at a specified location on a device or component lead.
Leakage Current, I_D	The maximum current that flows through the device at the rated stand-off voltage (V_{WM}) for a specified temperature. Also known as I_R for Reverse Leakage Current.
Line Thruput Resistance, R	The series resistance measured between line-in to line-out of a two stage transient voltage suppression device.
Maximum Clamping Voltage, V_{CM}	The maximum peak voltage appearing across the TVS when subjected to the rated peak pulse current I_{PPM} for a specified waveshape. The peak pulse voltage is a combination of voltage rise due to both the series resistance and the thermal rise.
Maximum Peak Pulse Current, I_{PPM}	The rated maximum value of the peak impulse current (I_{PP}) that may be applied without causing diode failure for a specified waveshape.
Minimum Breakdown Voltage, $V_{(BR)min}$	The minimum breakdown (avalanche) voltage a device will exhibit at a specified pulsed dc current.

TERM & SYMBOL**DESCRIPTION**

Non-Repetitive On-State Current, I_{TSM}	The rated peak value of the ac power frequency on-state current of a specified waveshape and frequency which may be applied for a specified time or number of cycles.
Off-State Current, I_D	The dc value of current that results from the application of the off-state voltage, V_D .
Off-State Voltage, V_D	The dc voltage when the device is in the off state.
On-State Current, I_T	The current through the device in the on-state condition.
On-State Voltage, V_T	The voltage across the device in the on-state condition at a specified current, I_T .
Operating Current, I_O	The continuous maximum line current of a device.
Operating Voltage, V_{OP}	The maximum voltage which is continuously applied to an I/O port or bus voltage without causing any degradation in the transmission characteristics due to the transient voltage suppressor (TVS).
Peak Overshoot Voltage, V_{OS}	The excess voltage above the clamping voltage (V_C) of the device for a given current that occurs when the current waves of less than 10 μ s virtual front duration are applied. This value may be expressed as a percentage of the clamping voltage (V_C) for a 10/1000 μ s waveshape.
Peak Pulse Current, I_{PP}	The peak pulse current applied to a device for a specified waveshape.
Peak Pulse Power Dissipation, P_{PP}	The peak pulse power dissipation resulting from the product of pulse current (I_{PP}) and clamping voltage: $P_{PP} = I_{PP} \times V_C$
Pulse Duration, t_d	The time for an impulse waveshape to decrease to 50% of its peak value measured from t_0 to peak.
Rated Stand-Off Voltage, V_{WM}	The maximum continuous dc or peak voltage which may be applied over the standard operating temperature range.
Repetitive Peak Off-State Current, I_{DRM}	The peak value of the off-state current that results from the application of the repetitive peak off-state voltage (V_{DRM}).
Repetitive Peak Off-State Voltage, V_{DRM}	The rated peak instantaneous voltage that may be applied in the off-state condition including all dc and repetitive alternating voltage components.
Repetitive Peak On-State Current, V_{TRM}	The rated maximum value of ac power frequency on-state current specified waveshape and frequency which may be applied continuously.
Repetitive Peak Reverse Current, I_{RRM}	The maximum value of the reverse current that results from the application of the repetitive peak reverse voltage (V_{RRM}).
Repetitive Peak Reserve Voltage, V_{RRM}	The rated maximum continuous voltage that may be applied in the reverse/blocking direction including all dc and repetitive alternating voltage components.
Reverse Leakage Current, I_R	The value of the reverse current that results from the application of the repetitive reverse voltage (V_{RR}).
Switching Current, I_S	The instantaneous current flowing through the device at the switching voltage, V_S .
Switching Voltage, V_S	The instantaneous voltage across the device at the final point in the breakdown region prior to switching into the on-state.
Thermal Resistance, $R_{\theta a}$, $R_{\theta j l}$	Junction to ambient, case or lead terminal temperature rise per unit of applied power expressed in degree Kelvin per watt.

Definitions provided by IEC 61647-2 & 61647-4 and Motorola.



SECTION 1

Cross-Reference Index
(Numeric/Alpha)

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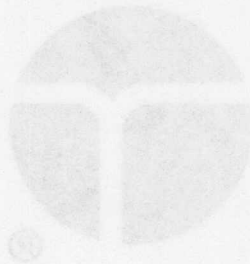
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CROSS REFERENCE GUIDE

The following Cross Reference Guide lists industry devices by their EIA, European, or in-house part numbers for which there is a direct or similar ProTek replacement. The direct replacement column shows the direct ProTek equivalent. The similar replacement column shows the nearest ProTek replacement. However the similar device may differ in electrical and/or case style from the referenced industry part number. Substitution acceptability can be determined by reviewing the Electrical Characteristics and Case Dimensions given within this databook. **In most situations, the electrical performance will exceed the original part.**

For devices not shown in the following Cross Reference Guide, or for further information, the user should contact ProTek Devices directly.



INDUSTRY PART NUMBER	PROTEK DIRECT REPLACEMENT	PROTEK SIMILAR REPLACEMENT	PAGE NUMBER	INDUSTRY PART NUMBER	PROTEK DIRECT REPLACEMENT	PROTEK SIMILAR REPLACEMENT	PAGE NUMBER	INDUSTRY PART NUMBER	PROTEK DIRECT REPLACEMENT	PROTEK SIMILAR REPLACEMENT	PAGE NUMBER
15KP100	15KP100		5-3	15KP45	15KP45		5-3	15KPA220CA	15KPA220CA		4-3
15KP100A	15KP100A		5-3	15KP45A	15KP45A		5-3	15KPA22A	15KPA22A		4-3
15KP100CA	15KP100CA		5-3	15KP45CA	15KP45CA		5-3	15KPA22CA	15KPA22CA		4-3
15KP110	15KP110		5-3	15KP48	15KP48		5-3	15KPA24	15KPA24		4-3
15KP110A	15KP110A		5-3	15KP48A	15KP48A		5-3	15KPA240	15KPA240		4-3
15KP110CA	15KP110CA		5-3	15KP48CA	15KP48CA		5-3	15KPA240A	15KPA240A		4-3
15KP120	15KP120		5-3	15KP51	15KP51		5-3	15KPA240CA	15KPA240CA		4-3
15KP120A	15KP120A		5-3	15KP51A	15KP51A		5-3	15KPA24A	15KPA24A		4-3
15KP120CA	15KP120CA		5-3	15KP51CA	15KP51CA		5-3	15KPA24CA	15KPA24CA		4-3
15KP130	15KP130		5-3	15KP54	15KP54		5-3	15KPA26	15KPA26		4-3
15KP130A	15KP130A		5-3	15KP54A	15KP54A		5-3	15KPA260	15KPA260		4-3
15KP130CA	15KP130CA		5-3	15KP54CA	15KP54CA		5-3	15KPA260A	15KPA260A		4-3
15KP150	15KP150		5-3	15KP58	15KP58		5-3	15KPA260CA	15KPA260CA		4-3
15KP150A	15KP150A		5-3	15KP58A	15KP58A		5-3	15KPA26A	15KPA26A		4-3
15KP150CA	15KP150CA		5-3	15KP58CA	15KP58CA		5-3	15KPA26CA	15KPA26CA		4-3
15KP160	15KP160		5-3	15KP60	15KP60		5-3	15KPA28	15KPA28		4-3
15KP160A	15KP160A		5-3	15KP60A	15KP60A		5-3	15KPA280	15KPA280		4-3
15KP160CA	15KP160CA		5-3	15KP60CA	15KP60CA		5-3	15KPA280A	15KPA280A		4-3
15KP17	15KP17		5-3	15KP64	15KP64		5-3	15KPA280CA	15KPA280CA		4-3
15KP170	15KP170		5-3	15KP64A	15KP64A		5-3	15KPA28A	15KPA28A		4-3
15KP170A	15KP170A		5-3	15KP64CA	15KP64CA		5-3	15KPA28CA	15KPA28CA		4-3
15KP170CA	15KP170CA		5-3	15KP70	15KP70		5-3	15KPA30	15KPA30		4-3
15KP17A	15KP17A		5-3	15KP70A	15KP70A		5-3	15KPA30A	15KPA30A		4-3
15KP17CA	15KP17CA		5-3	15KP70CA	15KP70CA		5-3	15KPA30CA	15KPA30CA		4-3
15KP18	15KP18		5-3	15KP75	15KP75		5-3	15KPA33	15KPA33		4-3
15KP180	15KP180		5-3	15KP75A	15KP75A		5-3	15KPA33A	15KPA33A		4-3
15KP180A	15KP180A		5-3	15KP75CA	15KP75CA		5-3	15KPA33CA	15KPA33CA		4-3
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15KP18A	15KP18A		5-3	15KP78A	15KP78A		5-3	15KPA36A	15KPA36A		4-3
15KP18CA	15KP18CA		5-3	15KP78CA	15KP78CA		5-3	15KPA36CA	15KPA36CA		4-3
15KP20	15KP20		5-3	15KP85	15KP85		5-3	15KPA40	15KPA40		4-3
15KP200	15KP200		5-3	15KP85A	15KP85A		5-3	15KPA40A	15KPA40A		4-3
15KP200A	15KP200A		5-3	15KP85CA	15KP85CA		5-3	15KPA40CA	15KPA40CA		4-3
15KP200CA	15KP200CA		5-3	15KP90	15KP90		5-3	15KPA45	15KPA45		4-3
15KP20A	15KP20A		5-3	15KP90A	15KP90A		5-3	15KPA45A	15KPA45A		4-3
15KP20CA	15KP20CA		5-3	15KP90CA	15KP90CA		5-3	15KPA45CA	15KPA45CA		4-3
15KP22	15KP22		5-3	15KPA100	15KPA100		4-3	15KPA48	15KPA48		4-3
15KP220	15KP220		5-3	15KPA100A	15KPA100A		4-3	15KPA48A	15KPA48A		4-3
15KP220A	15KP220A		5-3	15KPA100CA	15KPA100CA		4-3	15KPA48CA	15KPA48CA		4-3
15KP220CA	15KP220CA		5-3	15KPA110	15KPA110		4-3	15KPA51	15KPA51		4-3
15KP22A	15KP22A		5-3	15KPA110A	15KPA110A		4-3	15KPA51A	15KPA51A		4-3
15KP22CA	15KP22CA		5-3	15KPA110CA	15KPA110CA		4-3	15KPA51CA	15KPA51CA		4-3
15KP24	15KP24		5-3	15KPA120	15KPA120		4-3	15KPA54	15KPA54		4-3
15KP240	15KP240		5-3	15KPA120A	15KPA120A		4-3	15KPA54A	15KPA54A		4-3
15KP240A	15KP240A		5-3	15KPA120CA	15KPA120CA		4-3	15KPA54CA	15KPA54CA		4-3
15KP240CA	15KP240CA		5-3	15KPA130	15KPA130		4-3	15KPA58	15KPA58		4-3
15KP24A	15KP24A		5-3	15KPA130A	15KPA130A		4-3	15KPA58A	15KPA58A		4-3
15KP24CA	15KP24CA		5-3	15KPA130CA	15KPA130CA		4-3	15KPA58CA	15KPA58CA		4-3
15KP26	15KP26		5-3	15KPA150	15KPA150		4-3	15KPA60	15KPA60		4-3
15KP260	15KP260		5-3	15KPA150A	15KPA150A		4-3	15KPA60A	15KPA60A		4-3
15KP260A	15KP260A		5-3	15KPA150CA	15KPA150CA		4-3	15KPA60CA	15KPA60CA		4-3
15KP26CA	15KP26CA		5-3	15KPA160	15KPA160		4-3	15KPA64	15KPA64		4-3
15KP26A	15KP26A		5-3	15KPA160A	15KPA160A		4-3	15KPA64A	15KPA64A		4-3
15KP26CA	15KP26CA		5-3	15KPA160CA	15KPA160CA		4-3	15KPA64CA	15KPA64CA		4-3
15KP28	15KP28		5-3	15KPA17	15KPA17		4-3	15KPA70	15KPA70		4-3
15KP280	15KP280		5-3	15KPA170	15KPA170		4-3	15KPA70A	15KPA70A		4-3
15KP280A	15KP280A		5-3	15KPA170A	15KPA170A		4-3	15KPA70CA	15KPA70CA		4-3
15KP280CA	15KP280CA		5-3	15KPA170CA	15KPA170CA		4-3	15KPA75	15KPA75		4-3
15KP28A	15KP28A		5-3	15KPA17A	15KPA17A		4-3	15KPA75A	15KPA75A		4-3
15KP28CA	15KP28CA		5-3	15KPA17CA	15KPA17CA		4-3	15KPA75CA	15KPA75CA		4-3
15KP30	15KP30		5-3	15KPA18	15KPA18		4-3	15KPA78	15KPA78		4-3
15KP30A	15KP30A		5-3	15KPA180	15KPA180		4-3	15KPA78A	15KPA78A		4-3
15KP30CA	15KP30CA		5-3	15KPA180A	15KPA180A		4-3	15KPA78CA	15KPA78CA		4-3
15KP33	15KP33		5-3	15KPA180CA	15KPA180CA		4-3	15KPA85	15KPA85		4-3
15KP33A	15KP33A		5-3	15KPA18A	15KPA18A		4-3	15KPA85A	15KPA85A		4-3
15KP33CA	15KP33CA		5-3	15KPA18CA	15KPA18CA		4-3	15KPA85CA	15KPA85CA		4-3
15KP36	15KP36		5-3	15KPA20	15KPA20		4-3	15KPA90	15KPA90		4-3
15KP36A	15KP36A		5-3	15KPA200	15KPA200		4-3	15KPA90A	15KPA90A		4-3
15KP36CA	15KP36CA		5-3	15KPA200A	15KPA200A		4-3	15KPA90CA	15KPA90CA		4-3
15KP40	15KP40		5-3	15KPA200CA	15KPA200CA		4-3	15KS100	15KP100		5-3
15KP40A	15KP40A		5-3	15KPA20A	15KPA20A		4-3	15KS100A	15KP100A		5-3
15KP40CA	15KP40CA		5-3	15KPA20CA	15KPA20CA		4-3	15KS100CA	15KP100CA		5-3
15KP43	15KP43		5-3	15KPA22	15KPA22		4-3	15KS110	15KP110		5-3
15KP43A	15KP43A		5-3	15KPA220	15KPA220		4-3	15KS110A	15KP110A		5-3
15KP43CA	15KP43CA		5-3	15KPA220A	15KPA220A		4-3	15KS110CA	15KP110CA		5-3

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15KS120	15KP120		5-3	15KS51	15KP51		5-3	704-15K36H3	704-15K36H3		5-7
15KS120A	15KP120A		5-3	15KS51A	15KP51A		5-3	704-15K36T	704-15K36T		5-7
15KS120CA	15KP120CA		5-3	15KS51CA	15KP51CA		5-3	704-15K36TH1	704-15K36TH1		5-7
15KS130	15KP130		5-3	15KS54	15KP54		5-3	704-15K36TH2	704-15K36TH2		5-7
15KS130A	15KP130A		5-3	15KS54A	15KP54A		5-3	704-15K36TH3	704-15K36TH3		5-7
15KS130CA	15KP130CA		5-3	15KS54CA	15KP54CA		5-3	74F1071SC	PSMDA05-18		2-31
15KS150	15KP150		5-3	15KS58	15KP58		5-3	90KS200C	90KS200C		5-5
15KS150A	15KP150A		5-3	15KS58A	15KP58A		5-3	90KS200CH1	90KS200CH1		5-5
15KS150CA	15KP150CA		5-3	15KS58CA	15KP58CA		5-3	90KS200CH2	90KS200CH2		5-5
15KS160	15KP160		5-3	15KS60	15KP60		5-3	90KS200CH3	90KS200CH3		5-5
15KS160A	15KP160A		5-3	15KS60A	15KP60A		5-3	CPE80	CPE80		6-27
15KS160CA	15KP160CA		5-3	15KS60CA	15KP60CA		5-3	CX12	CX12		6-25
15KS17	15KP17		5-3	15KS64	15KP64		5-3	CX12LC	CX12LC		6-25
15KS170	15KP170		5-3	15KS64A	15KP64A		5-3	DA05CL	DA05CL		2-3
15KS170A	15KP170A		5-3	15KS64CA	15KP64CA		5-3	DA05CM	DA05CM		2-3
15KS170CA	15KP170CA		5-3	15KS70	15KP70		5-3	DA05CN	DA05CN		2-5
15KS17A	15KP17A		5-3	15KS70A	15KP70A		5-3	DA05CP	DA05CP		2-5
15KS17CA	15KP17CA		5-3	15KS70CA	15KP70CA		5-3	DA05L	DA05L		2-3
15KS18	15KP18		5-3	15KS75	15KP75		5-3	DA05M	DA05M		2-3
15KS180	15KP180		5-3	15KS75A	15KP75A		5-3	DA05N	DA05N		2-5
15KS180A	15KP180A		5-3	15KS75CA	15KP75CA		5-3	DA05P	DA05P		2-5
15KS180CA	15KP180CA		5-3	15KS78	15KP78		5-3	DA12CL	DA12CL		2-3
15KS18A	15KP18A		5-3	15KS78A	15KP78A		5-3	DA12CM	DA12CM		2-3
15KS18CA	15KP18CA		5-3	15KS78CA	15KP78CA		5-3	DA12CN	DA12CN		2-5
15KS20	15KP20		5-3	15KS85	15KP85		5-3	DA12CP	DA12CP		2-5
15KS200	15KP200		5-3	15KS85A	15KP85A		5-3	DA12L	DA12L		2-3
15KS200A	15KP200A		5-3	15KS85CA	15KP85CA		5-3	DA12M	DA12M		2-3
15KS200CA	15KP200CA		5-3	15KS90	15KP90		5-3	DA12N	DA12N		2-5
15KS20A	15KP20A		5-3	15KS90A	15KP90A		5-3	DA12P	DA12P		2-5
15KS20CA	15KP20CA		5-3	15KS90CA	15KP90CA		5-3	DA15CL	DA15CL		2-3
15KS22	15KP22		5-3	232B	232B		6-3	DA15CM	DA15CM		2-3
15KS220	15KP220		5-3	232E	232E		6-3	DA15CN	DA15CN		2-5
15KS220A	15KP220A		5-3	420E212	420E212		6-5	DA15CP	DA15CP		2-5
15KS220CA	15KP220CA		5-3	420E225	420E225		6-5	DA15L	DA15L		2-3
15KS22A	15KP22A		5-3	420E228	420E228		6-5	DA15M	DA15M		2-3
15KS22CA	15KP22CA		5-3	420E236	420E236		6-5	DA15N	DA15N		2-5
15KS24	15KP24		5-3	420E250	420E250		6-5	DA15P	DA15P		2-5
15KS240	15KP240		5-3	420E260	420E260		6-5	DA24CL	DA24CL		2-3
15KS240A	15KP240A		5-3	420LB28	420LB28		6-7	DA24CM	DA24CM		2-3
15KS240CA	15KP240CA		5-3	420LB35	420LB35		6-7	DA24CN	DA24CN		2-5
15KS24A	15KP24A		5-3	420LB60	420LB60		6-7	DA24CP	DA24CP		2-5
15KS24CA	15KP24CA		5-3	420LE28	420LE28		6-7	DA24L	DA24L		2-3
15KS26	15KP26		5-3	420LE35	420LE35		6-7	DA24M	DA24M		2-3
15KS260	15KP260		5-3	420LE60	420LE60		6-7	DA24N	DA24N		2-5
15KS260A	15KP260A		5-3	422B	422B		6-9	DA24P	DA24P		2-5
15KS260CA	15KP260CA		5-3	422E	422E		6-9	DLTS-12	DLZ12		2-7
15KS26A	15KP26A		5-3	422ELC	422ELC		6-11	DLTS-12A	DLZ12A		2-7
15KS26CA	15KP26CA		5-3	485ELC	485ELC		6-11	DLTS-13C	DLZ13C		2-7
15KS28	15KP28		5-3	587B051	587B051		6-15	DLTS-13CA	DLZ13CA		2-7
15KS280	15KP280		5-3	587B051LP	587B051LP		6-19	DLTS-17	DLZ17		2-7
15KS280A	15KP280A		5-3	587B062	587B062		6-17	DLTS-17A	DLZ17A		2-7
15KS280CA	15KP280CA		5-3	587B062LP	587B062LP		6-21	DLTS-19C	DLZ19C		2-7
15KS28A	15KP28A		5-3	587B062LPE	587B062LPE		6-23	DLTS-19CA	DLZ19CA		2-7
15KS28CA	15KP28CA		5-3	587B101LP	587B101LP		6-19	DLTS-24	DLZ24		2-7
15KS30	15KP30		5-3	587B102LP	587B102LP		6-21	DLTS-24A	DLZ24A		2-7
15KS30A	15KP30A		5-3	587B102LPE	587B102LPE		6-23	DLTS-30	DLZ30		2-7
15KS30CA	15KP30CA		5-3	587B151	587B151		6-15	DLTS-30A	DLZ30A		2-7
15KS33	15KP33		5-3	587B151LP	587B151LP		6-19	DLTS-30C	DLZ30C		2-7
15KS33A	15KP33A		5-3	587B162	587B162		6-17	DLTS-30CA	DLZ30CA		2-7
15KS33CA	15KP33CA		5-3	587B162LP	587B162LP		6-21	DLTS-5	DLZ5		2-7
15KS36	15KP36		5-3	587B162LPE	587B162LPE		6-23	DLTS-5A	DLZ5A		2-7
15KS36A	15KP36A		5-3	587B201	587B201		6-15	DLTS-8C	DLZ8C		2-7
15KS36CA	15KP36CA		5-3	587B201LP	587B201LP		6-19	DLTS-8CA	DLZ8CA		2-7
15KS40	15KP40		5-3	587B301	587B301		6-15	DLZ12	DLZ12		2-7
15KS40A	15KP40A		5-3	587B301LP	587B301LP		6-19	DLZ12A	DLZ12A		2-7
15KS40CA	15KP40CA		5-3	587B302	587B302		6-17	DLZ13C	DLZ13C		2-7
15KS43	15KP43		5-3	587B302LP	587B302LP		6-21	DLZ13CA	DLZ13CA		2-7
15KS43A	15KP43A		5-3	587B302LPE	587B302LPE		6-23	DLZ17	DLZ17		2-7
15KS43CA	15KP43CA		5-3	60KS200C	60KS200C		5-5	DLZ17A	DLZ17A		2-7
15KS45	15KP45		5-3	60KS200CH1	60KS200CH1		5-5	DLZ19C	DLZ19C		2-7
15KS45A	15KP45A		5-3	60KS200CH2	60KS200CH2		5-5	DLZ19CA	DLZ19CA		2-7
15KS45CA	15KP45CA		5-3	60KS200CH3	60KS200CH3		5-5	DLZ24	DLZ24		2-7
15KS48	15KP48		5-3	704-15K36	704-15K36		5-7	DLZ24A	DLZ24A		2-7
15KS48A	15KP48A		5-3	704-15K36H1	704-15K36H1		5-7	DLZ30	DLZ30		2-7
15KS48CA	15KP48CA		5-3	704-15K36H2	704-15K36H2		5-7	DLZ30A	DLZ30A		2-7

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DLZ30C	DLZ30C		2-7	P1500SB	PP1500SB		4-5	PP1800SB	PP1800SB		4-5
DLZ30CA	DLZ30CA		2-7	P1500SC	PP1500SC		4-5	PP1800SC	PP1800SC		4-5
DLZ5	DLZ5		2-7	P1800SA	PP1800SA		4-5	PP2300SA	PP2300SA		4-5
DLZ5A	DLZ5A		2-7	P1800SB	PP1800SB		4-5	PP2300SB	PP2300SB		4-5
DLZ8C	DLZ8C		2-7	P1800SC	PP1800SC		4-5	PP2300SC	PP2300SC		4-5
DLZ8CA	DLZ8CA		2-7	P2300SA	PP2300SA		4-5	PP2600SA	PP2600SA		4-5
EMC12F-LC	EMC12F-LC		2-9	P2300SB	PP2300SB		4-5	PP2600SB	PP2600SB		4-5
EMC15F-LC	EMC15F-LC		2-9	P2300SC	PP2300SC		4-5	PP2600SC	PP2600SC		4-5
EMC3.3F-LC	EMC3.3F-LC		2-9	P2600SA	PP2600SA		4-5	PP3100SA	PP3100SA		4-5
EMC5.0F-LC	EMC5.0F-LC		2-9	P2600SB	PP2600SB		4-5	PP3100SB	PP3100SB		4-5
EMC8.0F-LC	EMC8.0F-LC		2-9	P2600SC	PP2600SC		4-5	PP3100SC	PP3100SC		4-5
ESDA14V2L	PSOT12C	PSMS12	2-37	P3100SA	PP3100SA		4-5	PP3500SA	PP3500SA		4-5
ESDA14V2SC5			2-33	P3100SB	PP3100SB		4-5	PP3500SB	PP3500SB		4-5
ESDA14V2SC6	PSMS12		2-33	P3100SC	PP3100SC		4-5	PP3500SC	PP3500SC		4-5
ESDA6V1L	PSOT05C		2-37	P3500SA	PP3500SA		4-5	PSLC03	PSLC03		2-21
ESDA6V1S3	PSMDA05-18		2-31	P3500SB	PP3500SB		4-5	PSLC03C	PSLC03C		2-21
ESDA6V1SC5		PSMS05	2-33	P3500SC	PP3500SC		4-5	PSLC05	PSLC05		2-21
ESDA6V1SC6	PSMS05		2-33	PHP120	PHP120		5-11	PSLC05C	PSLC05C		2-21
ESDA6V1U1	PSMDA05-6		2-27	PHP208	PHP208		5-11	PSLC08	PSLC08		2-21
GPZ1275	GPZ1275		5-9	PHP24	PHP24		5-11	PSLC08C	PSLC08C		2-21
GPZ532	GPZ532		5-9	PHP250	PHP250		5-11	PSLC12	PSLC12		2-21
ITA10B3	SM20MT08C		2-63	PHP30	PHP30		5-11	PSLC12C	PSLC12C		2-21
ITA18B3	SM20MT15C		2-63	PHP440	PHP440		5-11	PSLC15	PSLC15		2-21
ITA25B3	SM20MT24C		2-63	PHP500	PHP500		5-11	PSLC15C	PSLC15C		2-21
ITA6V5B3	SM20MT05C		2-63	PHP60	PHP60		5-11	PSLC24	PSLC24		2-21
LC01-6	PLC01-6		2-15	PHP8.4	PHP8.4		5-11	PSLC24C	PSLC24C		2-21
LC03-6	PLC03-6		2-17	PIP120	PIP120		5-11	PSM712	PSM712		2-23
LCA05C	LCA05C		2-11	PIP208	PIP208		5-11	PSMDA05-18	PSMDA05-18		2-31
LCA08C	LCA08C		2-11	PIP24	PIP24		5-11	PSMDA05-6	PSMDA05-6		2-27
LCA12C	LCA12C		2-11	PIP250	PIP250		5-11	PSMDA05C-4	PSMDA05C-4		2-25
LCA15C	LCA15C		2-11	PIP30	PIP30		5-11	PSMDA05C-8	PSMDA05C-8		2-29
LCA24C	LCA24C		2-11	PIP440	PIP440		5-11	PSMDA12C-4	PSMDA12C-4		2-25
LCD05C	LCD05C		2-13	PIP500	PIP500		5-11	PSMDA12C-8	PSMDA12C-8		2-29
LCD08C	LCD08C		2-13	PIP60	PIP60		5-11	PSMDA15C-4	PSMDA15C-4		2-25
LCD12C	LCD12C		2-13	PIP8.4	PIP8.4		5-11	PSMDA15C-8	PSMDA15C-8		2-29
LCD15C	LCD15C		2-13	PLC01-6	PLC01-6		2-15	PSMDA24C-4	PSMDA24C-4		2-25
LCD24C	LCD24C		2-13	PLC03-6	PLC03-6		2-17	PSMDA24C-8	PSMDA24C-8		2-29
LCDA05	PLCDA05		2-19	PLCDA03	PLCDA03		2-19	PSMS05	PSMS05		2-33
LCD12	PLCDA12		2-19	PLCDA05	PLCDA05		2-19	PSMS05C	PSMS05C		2-35
LCD15	PLCDA15		2-19	PLCDA12	PLCDA12		2-19	PSMS12	PSMS12		2-33
LCD24	PLCDA24		2-19	PLCDA15	PLCDA15		2-19	PSMS12C	PSMS12C		2-35
LC03-6	PLC03-6		2-17	PLCDA24	PLCDA24		2-19	PSMS15	PSMS15		2-33
MAD1103	PMAD1103		3-3	PMAD1103	PMAD1103		3-3	PSMS15C	PSMS15C		2-35
MAD1105	PMAD1105		3-3	PMAD1105	PMAD1105		3-3	PSMS24	PSMS24		2-33
MAD1106	PMAD1106		3-3	PMAD1106	PMAD1106		3-3	PSMS24C	PSMS24C		2-35
MAD1107	PMAD1107		3-3	PMAD1107	PMAD1107		3-3	PSOT03	PSOT03		2-37
MAD1108	PMAD1108		3-3	PMAD1108	PMAD1108		3-3	PSOT03C	PSOT03C		2-37
MAD1109	PMAD1109		3-3	PMAD1109	PMAD1109		3-3	PSOT03LC	PSOT03LC		2-39
MAD130	PMAD130		3-3	PMAD130	PMAD130		3-3	PSOT05	PSOT05		2-37
MB80	MB80		6-27	PMMAD1103	PMMAD1103		3-5	PSOT05C	PSOT05C		2-37
MMAD1103	PMMAD1103		3-5	PMMAD1105	PMMAD1105		3-5	PSOT05LC	PSOT05LC		2-39
MMAD1105	PMMAD1105		3-5	PMMAD1106	PMMAD1106		3-5	PSOT08	PSOT08		2-37
MMAD1106	PMMAD1106		3-5	PMMAD1107	PMMAD1107		3-5	PSOT08C	PSOT08C		2-37
MMAD1107	PMMAD1107		3-5	PMMAD1108	PMMAD1108		3-7	PSOT08LC	PSOT08LC		2-39
MMAD1108	PMMAD1108		3-7	PMMAD1109	PMMAD1109		3-5	PSOT12	PSOT12		2-37
MMAD1109	PMMAD1109		3-5	PMMAD130	PMMAD130		3-5	PSOT12C	PSOT12C		2-37
MMAD130	PMMAD130		3-5	PP0640SA	PP0640SA		4-5	PSOT12LC	PSOT12LC		2-39
MMBZ15VDLT	PSOT15VCC		CF	PP0640SB	PP0640SB		4-5	PSOT15	PSOT15		2-37
MMBZ5V6ALT	PSOT5.6VCA		CF	PP0640SC	PP0640SC		4-5	PSOT15C	PSOT15C		2-37
P0640SA	PP0640SA		4-5	PP0720SA	PP0720SA		4-5	PSOT15LC	PSOT15LC		2-39
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P0640SC	PP0640SC		4-5	PP0720SC	PP0720SC		4-5	PSOT24C	PSOT24C		2-37
P0720SA	PP0720SA		4-5	PP0800SA	PP0800SA		4-5	PSOT24LC	PSOT24LC		2-39
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SMLJ78	SMDJ78		4-9	VS10P05LC	VS10P05LC		2-67	VS10P24LCI	VS10P24LCI		2-67
SMLJ78A	SMDJ78A		4-9	VS10P05LCI	VS10P05LCI		2-67	VS10P24LCI	VS10P24LCI		2-67
SMLJ78C	SMDJ78C		4-9	VS10P08	VS10P08		2-67	VS10P24LCI	VS10P24LCI		2-67
SMLJ78CA	SMDJ78CA		4-9	VS10P08C	VS10P08C		2-67	VS10P24LCI	VS10P24LCI		2-67
SMLJ8.0	SMDJ8.0		4-9	VS10P08LC	VS10P08LC		2-67	VS10P24LCI	VS10P24LCI		2-67
SMLJ8.0A	SMDJ8.0A		4-9	VS10P08LCI	VS10P08LCI		2-67	VS10P24LCI	VS10P24LCI		2-67
SMLJ8.0C	SMDJ8.0C		4-9	VS10P12	VS10P12		2-67	VS10P24LCI	VS10P24LCI		2-67
SMLJ8.0CA	SMDJ8.0CA		4-9	VS10P12C	VS10P12C		2-67	VS10P24LCI	VS10P24LCI		2-67

SECTION 2

Transient Voltage Suppressor Arrays

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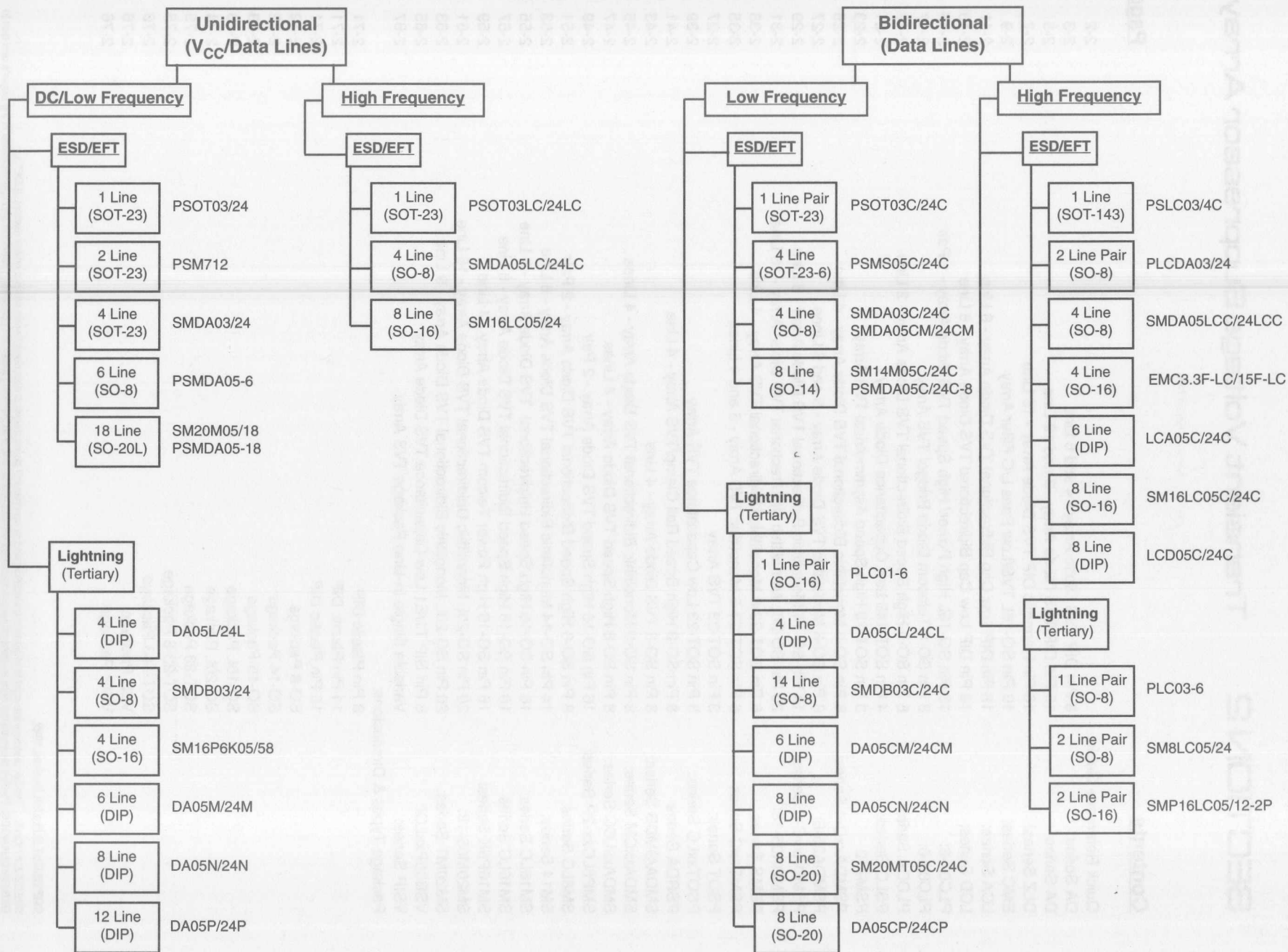
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DESIGN CHANGES: ProTek reserves the right to discontinue product lines without notice, and that the final judgement concerning selection and specifications is the buyer's and that in furnishing engineering and technical assistance, ProTek assumes no responsibility with respect to the selection or specifications of such products.

AVALANCHE BREAKDOWN (TVS) DIODES QUICK REFERENCE GUIDE



TVS DIODE ARRAY

APPLICATIONS

- RS-232 & RS-423 Data Lines
- Microprocessor Based Equipment
- Low Frequency I/O Ports
- Power Bus Lines
- Monitoring & Industrial Data Ports

FEATURES

- Meets IEC 1000-4-2, -4 & -5 Industry Requirements
- 500 Watts Peak Pulse Power Dissipation (8/20 μ s)
- Available in 4 Voltage Types Ranging from 5.0V to 24V
- ESD Protection > 40 kilovolts
- Standard Dual-in-Line Package
- Internal Common Ground
- UL 94V-0 Flammability Classification

DESCRIPTION

This eight (8) pin diode array family is a series of silicon transient voltage suppressors (TVS) designed for use in applications where voltage transients such as ESD, EFT and tertiary lightning can permanently damage sensitive components or equipment. This device protects against the Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4, -5 and European standard EN50082.

This series has a peak pulse power (P_{PP}) rating of 500 Watts for an 8/20 μ s waveshape. Typically, the DA series can be used to protect a combination of 4 to 6 unidirectional or bidirectional lines with two ground pins per package for a low impedance ground connection.

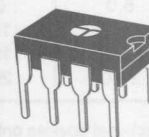
MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	500 Watts, 8/20 μ s Waveshape
Forward Surge Rating	10A, 1/120 seconds @ 25°C (Unidirectional Only)
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds

MECHANICAL CHARACTERISTICS

Package	Molded Plastic 8 Pin Dual-in-Line Package
Common Ground Pins	Pin Nos. 1 & 8
Approximate Weight	0.55 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

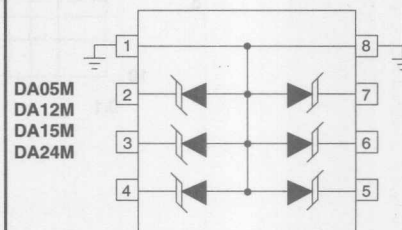
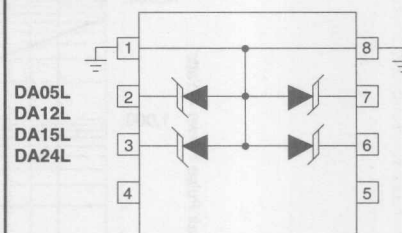
IEC 1000-4 COMPATIBLE



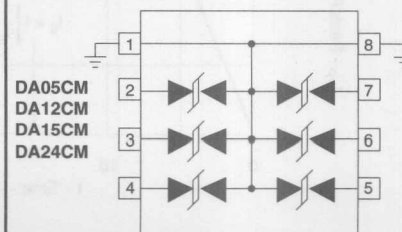
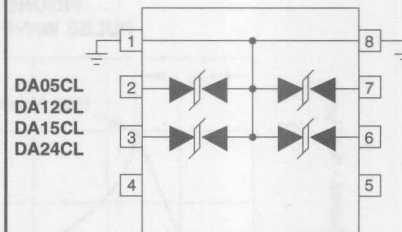
8 PIN PLASTIC DIP

CIRCUIT DIAGRAMS

UNIDIRECTIONAL



BIDIRECTIONAL



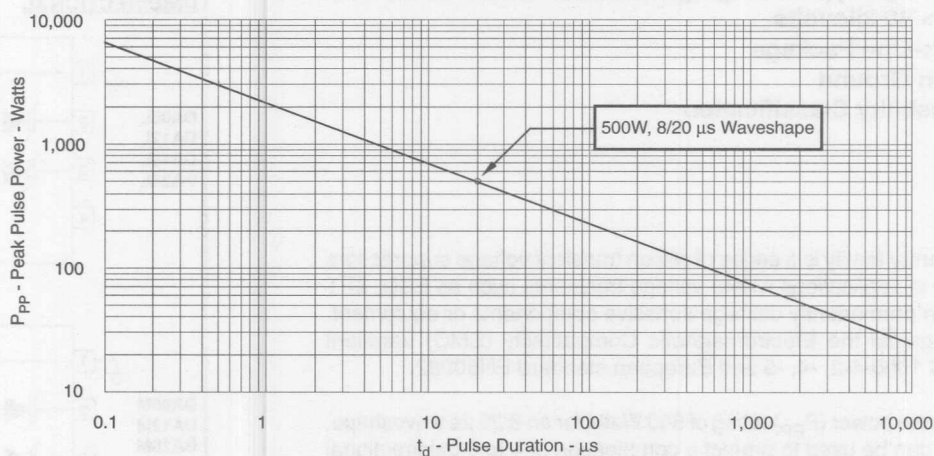
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1)	UNIDIRECTIONAL					BIDIRECTIONAL				
	RATED STAND-OFF VOLTAGE	MINIMUM BREAKDOWN VOLTAGE	MAXIMUM CLAMPING VOLTAGE	MAXIMUM LEAKAGE CURRENT	MAXIMUM CAPACITANCE	RATED STAND-OFF VOLTAGE	MINIMUM BREAKDOWN VOLTAGE	MAXIMUM CLAMPING VOLTAGE	MAXIMUM LEAKAGE CURRENT	MAXIMUM CAPACITANCE
	(See Note 2)	@ 1 mA	@ $I_P = 10$ A	@ V_{WM}	@ 0V, 1 MHz	(See Note 1)	@ 1 mA	@ $I_P = 10$ A	@ V_{WM}	@ 0V, 1 MHz
	V_{WM} VOLTS	$V_{(BR)}$ VOLTS	V_C VOLTS	I_D μ A	C pF	V_{WM} VOLTS	$V_{(BR)}$ VOLTS	V_C VOLTS	I_D μ A	C pF
See Circuit Diagram	5.0	6.0	12.5	200	880	5.0	6.0	12.5	200	500
	12.0	13.3	26.0	2	440	12.0	13.3	26.0	2	385
	15.0	16.7	33.0	2	400	15.0	16.7	33.0	2	300
	24.0	26.7	52.1	2	275	24.0	26.7	52.1	2	200

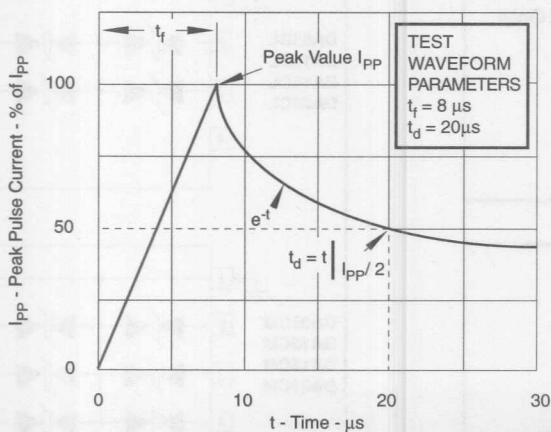
Note 1: For unidirectional devices only; $V_F = 1.5$ Volts @ 100mA, 300 μ s (square wave).

Note 2: Use DA05L, DA05M, DA05CL, DA05CM for 5 Volt stand-off voltage, DA12L, DA12M, DA12CL, DA12CM for 12 Volt stand-off voltage, etc. . .

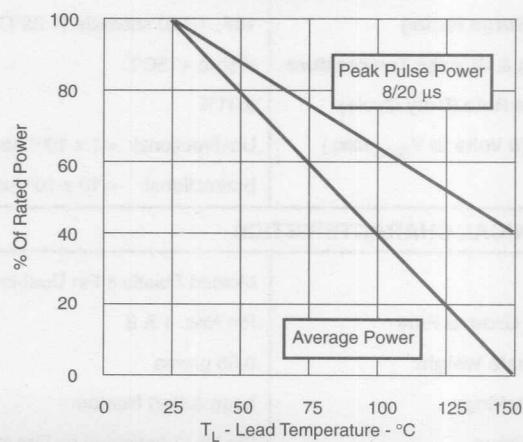
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



APPLICATIONS

- RS-232 & RS-423 Data Lines
- Microprocessor Based Equipment
- Low Frequency I/O Ports
- Power Bus Lines
- Monitoring & Industrial Data Ports

FEATURES

- Meets IEC 1000-4-2, -4 & -5 Industry Requirements
- 500 Watts Peak Pulse Power Dissipation (8/20 μ s)
- Available in 4 Voltage Types Ranging from 5.0V to 24V
- ESD Protection > 40 kilovolts
- Standard Dual-in-Line Package
- Internal Common Ground
- UL 94V-0 Flammability Classification

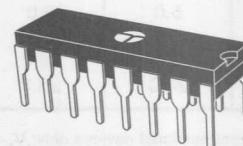
DESCRIPTION

This sixteen (16) pin diode array family is a series of silicon transient voltage suppressors (TVS) designed for use in applications where voltage transients such as ESD, EFT, and tertiary lightning can permanently damage sensitive components or equipment. This device protects against the Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4, -5 and European standard EN50082.

This series has a peak pulse power (P_{PP}) rating of 500 Watts for an 8/20 μ s waveshape. Typically, the DA series can be used to protect a combination of 8 to 12 unidirectional or bidirectional lines with four ground pins per package for a low impedance ground connection.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	500 Watts, 8/20 μ s Waveshape
Forward Surge Rating	10A, 1/120 seconds @ 25°C (Unidirectional Only)
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded Plastic 16 Pin Dual-in-Line Package
Common Ground Pins	Pin Nos. 1, 8, 9 & 16
Approximate Weight	1.2 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

IEC 1000-4 COMPATIBLE

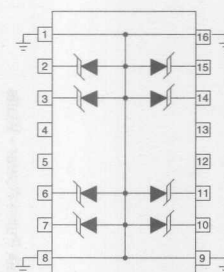


16 PIN PLASTIC DIP

CIRCUIT DIAGRAMS

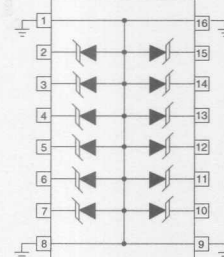
UNIDIRECTIONAL

DA05N
DA12N
DA15N
DA24N



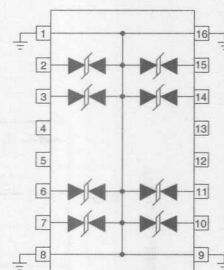
UNIDIRECTIONAL

DA05P
DA12P
DA15P
DA24P



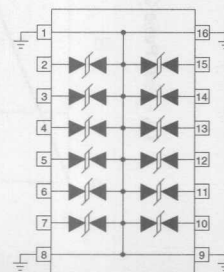
BIDIRECTIONAL

DA05CN
DA12CN
DA15CN
DA24CN



BIDIRECTIONAL

DA05CP
DA12CP
DA15CP
DA24CP



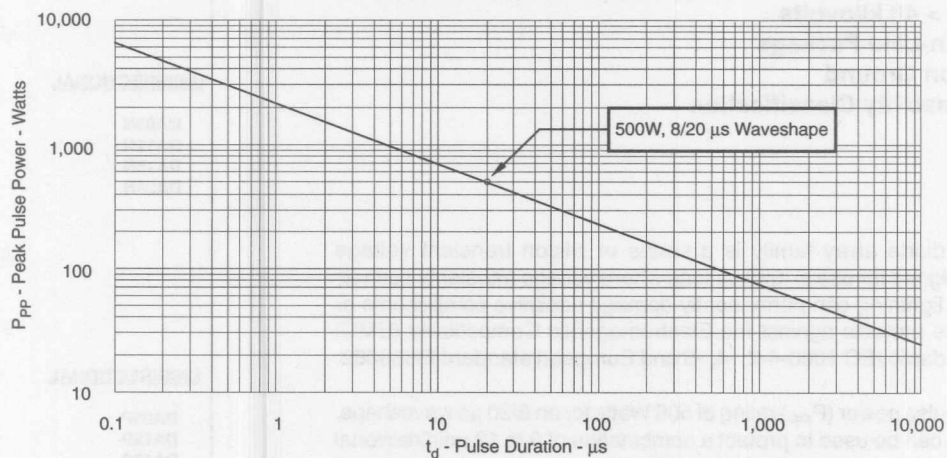
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1)	UNIDIRECTIONAL					BIDIRECTIONAL				
	RATED STAND-OFF VOLTAGE	MINIMUM BREAKDOWN VOLTAGE	MAXIMUM CLAMPING VOLTAGE	MAXIMUM LEAKAGE CURRENT	MAXIMUM CAPACITANCE	RATED STAND-OFF VOLTAGE	MINIMUM BREAKDOWN VOLTAGE	MAXIMUM CLAMPING VOLTAGE	MAXIMUM LEAKAGE CURRENT	MAXIMUM CAPACITANCE
	(See Note 2)	@ 1 mA	@ $I_P = 10$ A	@ V_{WM}	@ 0V, 1 MHz	(See Note 1)	@ 1 mA	@ $I_P = 10$ A	@ V_{WM}	@ 0V, 1 MHz
	V_{WM} VOLTS	$V_{(BR)}$ VOLTS	V_C VOLTS	I_D μ A	C pF	V_{WM} VOLTS	$V_{(BR)}$ VOLTS	V_C VOLTS	I_D μ A	C pF
See Circuit Diagram	5.0	6.0	12.5	200	880	5.0	6.0	12.5	200	500
	12.0	13.3	26.0	2	440	12.0	13.3	26.0	2	385
	15.0	16.7	33.0	2	400	15.0	16.7	33.0	2	300
	24.0	26.7	52.1	2	275	24.0	26.7	52.1	2	200

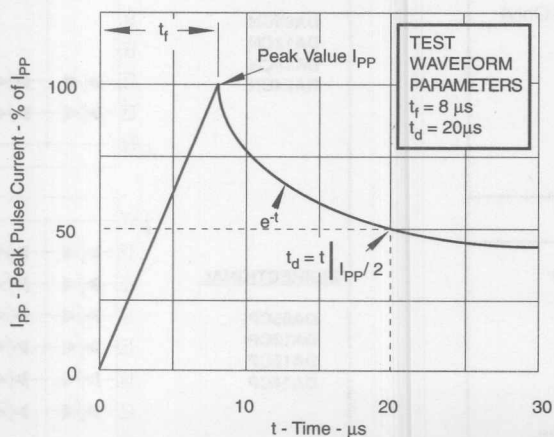
Note 1: For unidirectional devices only; $V_F = 1.5$ Volts @ 100mA, 300 μ s (square wave).

Note 2: Use DA05N, DA05P, DA05CN, DA05CP for 5 Volt stand-off voltage, DA12N, DA12P, DA12CN, DA12CP for 12 Volt stand-off voltage, etc. . .

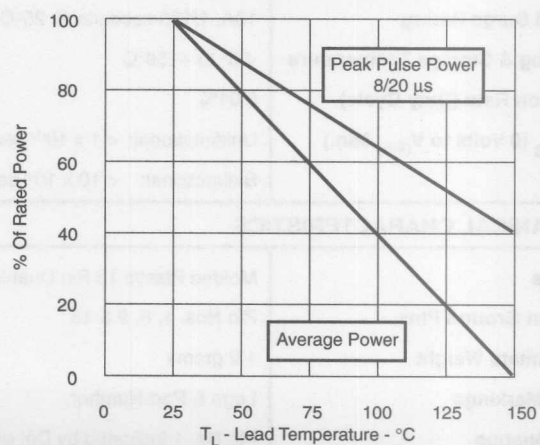
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



APPLICATIONS

- RS-232 & RS-423 Data Lines
- Microprocessor Based Equipment
- Low Frequency I/O Ports
- Multiple Data & Power Bus Line Protection
- Military & Aerospace Data Lines

FEATURES

- MIL-STD-461 Compatible
- 500 Watts Peak Pulse Power Dissipation (8/20 μ s)
- Available in 8 Voltage Types Ranging from 5.0V to 30V
- ESD Protection > 40 kilovolts
- Internal Common Ground
- Military Environmental Capability

DESCRIPTION

The DLZ 16 pin diode array family is a series of silicon transient voltage suppressors (TVS) available in a ceramic, hermetically sealed Dual-in-Line package for use in aerospace applications. In addition, the DLZ series offers protection of standard TTL and MOS bus lines in applications where NEMP, electrostatic discharge, and other induced voltage surges can damage or upset voltage sensitive circuitry. The DLZ series can be used to protect a combination of up to 15 unidirectional or bidirectional lines.

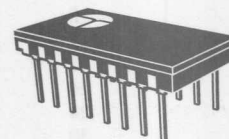
ProTek Devices offers the DLZ series screened for military requirements in accordance with MIL-PRF-19500. Standard screening consists of 100% JANTX equivalent level testing per MIL-PRF-19500/500 (unidirectional) and MIL-PRF-19500/507 (bidirectional). For ordering these options, use the following suffix:

- H1 - 100% JANTX level screening
- H2 - 100% JANTX level screening with Group B testing

This series is also screened to DESC drawing # 94029 (bidirectional) and #94030 (unidirectional).

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	500 Watts, 8/20 μ s Waveshape
Forward Surge Rating	10A, 1/120 seconds @ 25°C (Unidirectional Only)
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
t_{Clamping} (0 Volts to V_(BR) Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Ceramic 16 Pin Hermetically Sealed Package
Common Ground Pins	Depends on Configuration (See Circuit Diagrams)
Approximate Weight	3.2 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Flag on Lead

MIL-STD-461 COMPATIBLE

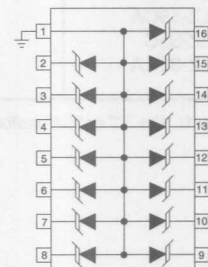


16 PIN CERAMIC PACKAGE

CIRCUIT DIAGRAMS

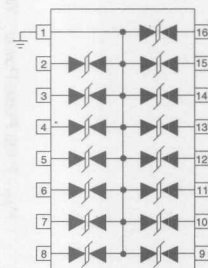
STANDARD UNIDIRECTIONAL

DLZ-5
DLZ-12
DLZ-17
DLZ-24
DLZ-30

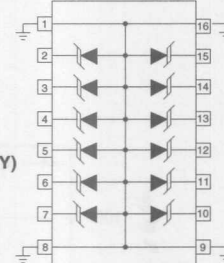


STANDARD BIDIRECTIONAL

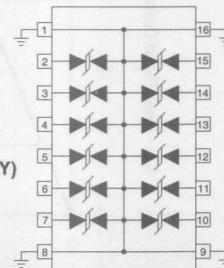
DLZ-8C
DLZ-13C
DLZ-19C
DLZ-30C



OPTIONAL UNIDIRECTIONAL PACKAGE (CONSULT FACTORY)



OPTIONAL BIDIRECTIONAL PACKAGE (CONSULT FACTORY)

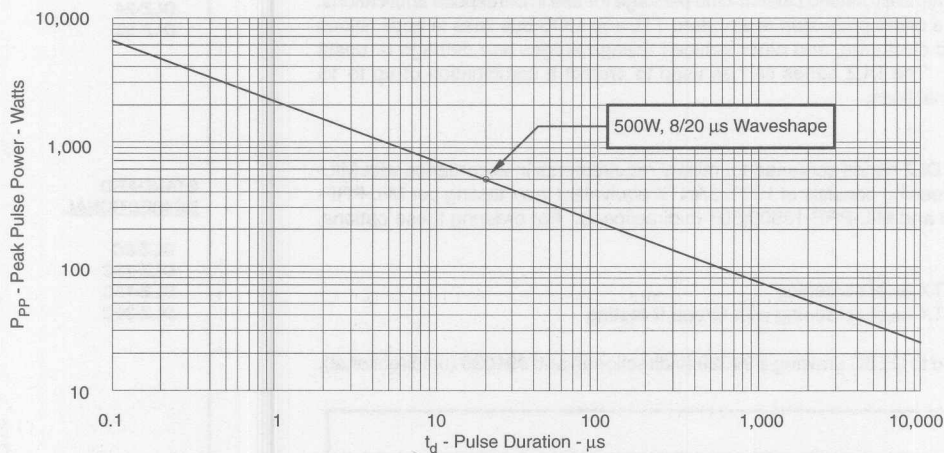


ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

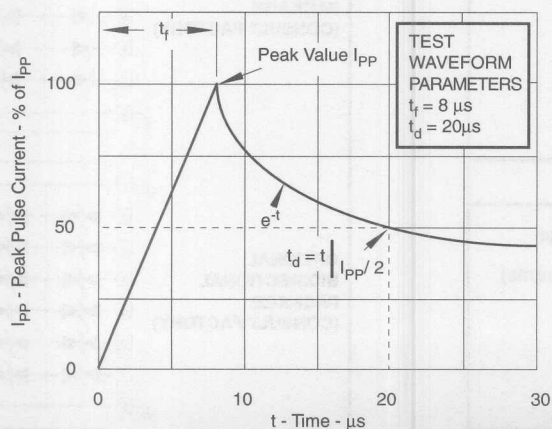
PROTEK PART NUMBER (See Note 1)	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1A$ V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 10 A$ V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF	TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
DLZ-5	5	6	10.2	12.5	200	880	5
DLZ-5A	5	6	9.5	10.6	200	880	5
DLZ-12	12	13.3	21.1	26.0	2	440	18
DLZ-12A	12	13.3	19.1	23.5	2	440	18
DLZ-17	17	19.2	30.4	37.4	2	330	20
DLZ-17A	17	19.2	27.5	33.9	2	330	20
DLZ-24	24	26.7	42.3	52.1	2	275	31
DLZ-24A	24	26.7	38.3	47.2	2	275	31
DLZ-30	30	33.3	52.8	65.0	2	220	39
DLZ-30A	30	33.3	47.8	58.8	2	220	39
DLZ-8C	8	8.5	13.4	16.6	10	440	9
DLZ-8CA	8	8.5	12.2	15.0	10	440	9
DLZ-13C	13	14.4	22.8	28.1	4	385	18
DLZ-13CA	13	14.4	20.6	25.4	4	385	18
DLZ-19C	19	21.6	34.2	42.1	4	275	24
DLZ-19CA	19	21.6	31.0	38.1	4	275	24
DLZ-30C	30	33.3	52.8	65.0	4	165	39
DLZ-30CA	30	33.3	47.8	58.8	4	165	39

Note 1: The "C" or "CA" suffix specifies a bidirectional device. Test both polarities.

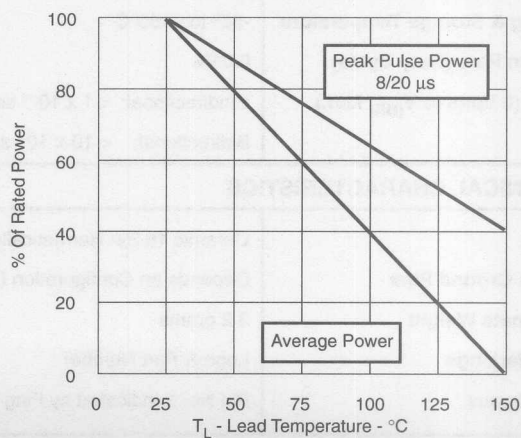
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



TVS/ LOW PASS L/C FILTER ARRAY

APPLICATIONS

- High Speed Interface Networks
- Graphics & Video Cards
- Global Positioning Systems
- Wireless Communications/ LANS
- EMI/RFI Low Pass Filtering
- Notebook & Desktop Computers

FEATURES

- EMI/RFI Protection
- L/C Bessel Filter
- Very Low Insertion Loss: < 0.5dB up to 200 MHz
- Excellent Matching Over the Operating Frequency
- Meets IEC 1000-4 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation (8/20 μ s)
- Protects 3.3 - 15 Volt I/O Ports
- Four (4), Two Port Networks
- 50 Ohm Network Terminations
- ESD Protection > 40 kilovolts

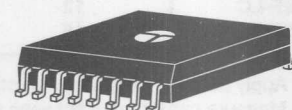
DESCRIPTION

The EMCxxF-LC consists of four, two port diode clamp and EMI/RFI filter networks. It is designed to provide complete Electromagnetic Compatibility (EMC) protection according to IEC 1000-4 requirements and European standard EN50082, EN61000-4 and EN300 386-2.

The transient voltage suppressor (TVS) and L/C filter components are configured in a Pi filter arrangement. This device includes four (4) isolated network circuits in a standard SO-16L, surface mount package. The EMCxxF-LC is a low capacitance device designed as one leg of a pi filter and offers protection for sensitive IC components. With the combination of active and passive components, this device reduces the reflections and ringing associated with high speed data line circuits.

MAXIMUM RATINGS	
P_{pp} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Repetition Rate (Duty Cycle)	0.01%
Operating & Storage Temperature	-55° to +150°C
Operating Current I_{mA} (DC)	100mA
t_{Clamping} (0 Volts to V_(BR) Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-16L Wide Body Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.5 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

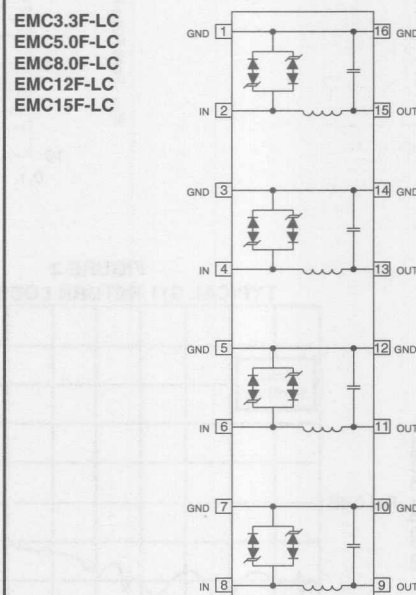
IEC 1000-4 COMPATIBLE



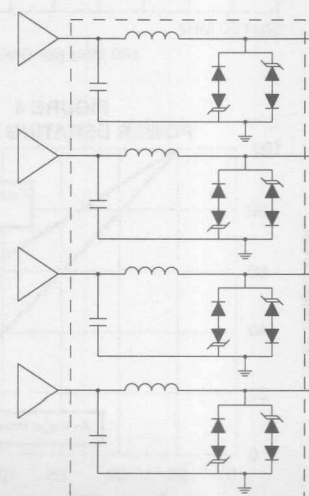
TVS
Arrays

SO-16L PACKAGE

CIRCUIT DIAGRAM



**TYPICAL APPLICATION
VIDEO BUFFER DRIVER: 50 Ω CABLES**



ELECTRICAL CHARACTERISTICS @ 25°C Ambient Temperature

PROTEK PART NUMBER	MAXIMUM OPERATING VOLTAGE $V_{(OP)}$ VOLTS	MINIMUM BREAKDOWN VOLTAGE (See Note 1) @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM LEAKAGE CURRENT (See Note 1) @ V_{WM} I_D μA	MAXIMUM CLAMPING VOLTAGE (See Fig. 5) @ $I_P = 5 A$ V_C VOLTS	TYPICAL OUTPUT CAPACITANCE (See Note 2) @ 0V, 1 MHz C pF	CUT-OFF FREQUENCY @ -3dB f_c MHz
EMC3.3F-LC	3.3	4.0	100	9.0	10	500
EMC5.0F-LC	5.0	6.0	50.0	11.0	10	500
EMC8.0F-LC	8.0	8.5	5.0	16.6	10	500
EMC12F-LC	12	13.3	5.0	24.0	10	500
EMC15F-LC	15	16.7	5.0	30.0	10	500

Note 1: Apply positive (negative) potential between input pins to ground pins, output open.

Note 2: Measure capacitance between output pins to ground pins.

FIGURE 1
PEAK PULSE VS PULSE TIME

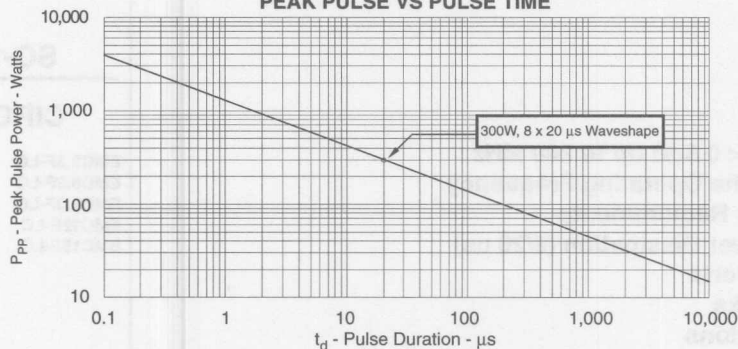


FIGURE 2
TYPICAL S11 RETURN LOSS CURVE

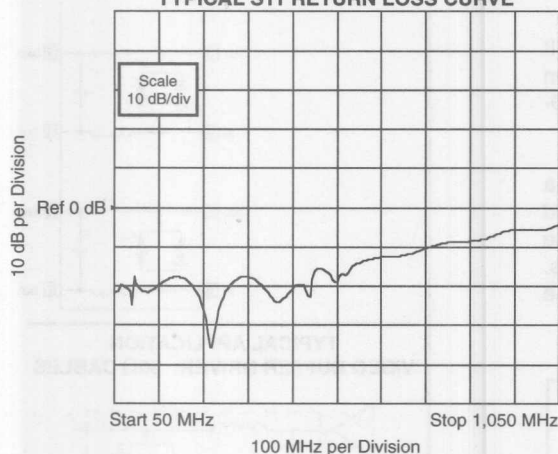


FIGURE 3
TYPICAL S12 INSERTION LOSS CURVE

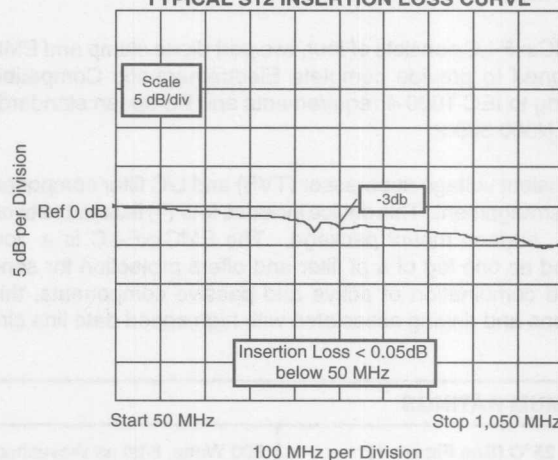


FIGURE 4
POWER DERATING CURVE

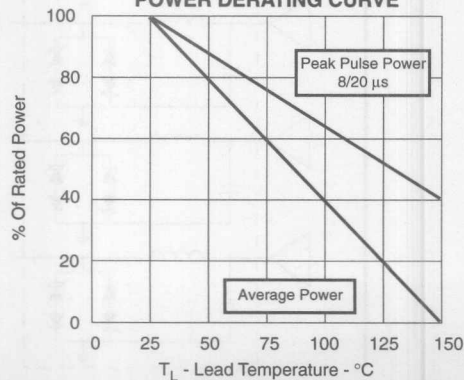
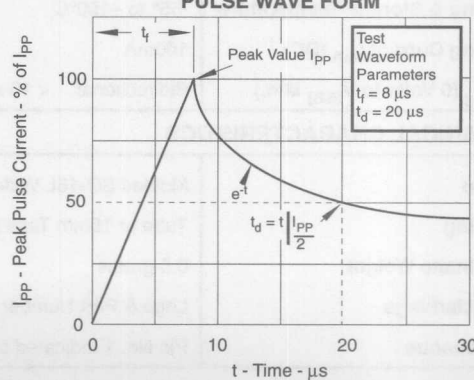


FIGURE 5
PULSE WAVE FORM



HIGH SPEED TVS DIODE ARRAY

APPLICATIONS

- RS-485, 100 Base T & Category 5 Data Lines
- Cellular Phones
- Network Interface Circuits: USB, ADSL, ISDN, SCSI, ATM & Ethernet
- Audio/Video I/O Ports

FEATURES

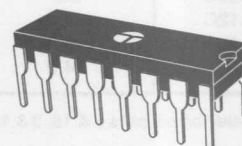
- Meets IEC 1000-4-2 & -4 Industry Requirements
- 500 Watts Peak Pulse Power Dissipation (8/20 μ s)
- Available in 5 Voltage Types Ranging from 5.0V to 24V
- ESD Protection > 40 kilovolts
- Standard Dual-in-Line Package
- Low Capacitance
- 6 Line Bidirectional Multiple-diode Array
- UL 94V-0 Flammability Classification

DESCRIPTION

This sixteen (16) pin bidirectional diode array family is a series of low capacitance, silicon transient voltage suppressors (TVS). The LCA was specifically designed for transient voltage suppression across signal or data lines at board level. These devices can be applied at the board interface or as protection of multiple IC components. The LCA series protects against the Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082, EN61000-4 and EN300 386-2.

This series has a peak pulse power (P_{PP}) rating of 500 Watts for an 8/20 μ s waveshape. Typically, the LCA series can be used to protect combinations of six (6) bidirectional signal lines on pin pairs (2 & 15), (3 & 14), (4 & 13), (5 & 12), (6 & 11) and (7 & 10). Pins 1, 8, 9, and 16 are not active and are for position only. The LCA device contains six (6) electrically isolated transient voltage suppressors; each consisting of two TVS diodes and 2 low capacitance diodes. There is no internal common ground.

IEC 1000-4 COMPATIBLE

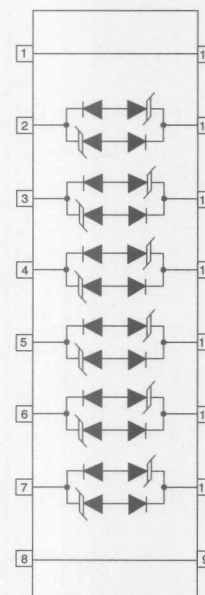


TVS
Arrays

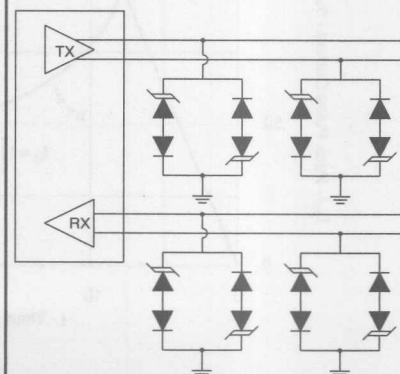
16 PIN PLASTIC DIP

CIRCUIT DIAGRAM

LCA05C
LCA08C
LCA12C
LCA15C
LCA24C



TRANSCEIVER (RS 485) APPLICATION



MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	500 Watts per Line, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to V_{BR} Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded Plastic 16 Pin Dual-in-Line Package
Approximate Weight	1.2 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

ELECTRICAL CHARACTERISTICS (Both directions) @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1)	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_p = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_p = 10$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF	TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
LCA05C	5.0	6.0	9.8	12.5	100	15	3
LCA08C	8.0	8.5	12.3	16.6	10	15	9
LCA12C	12.0	13.3	19.0	23.5	4	15	16
LCA15C	15.0	16.7	25.5	29.5	4	15	17
LCA24C	24.0	26.7	40.0	46.9	4	15	26

Note 1: Tested on pin pairs 2 & 15, 3 & 14, 4 & 13, 5 & 12, 6 & 11 and 7 & 10. Pins 1, 8, 9 and 16 are not active and are for position only.

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

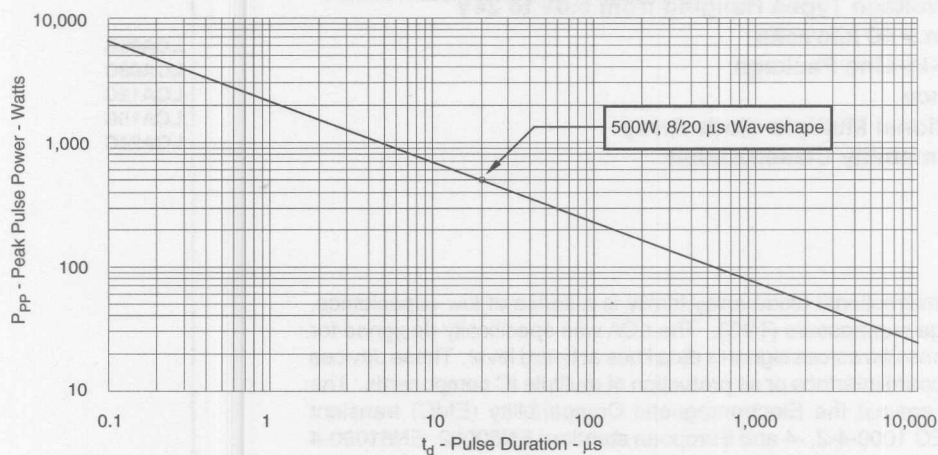


FIGURE 2
PULSE WAVE FORM

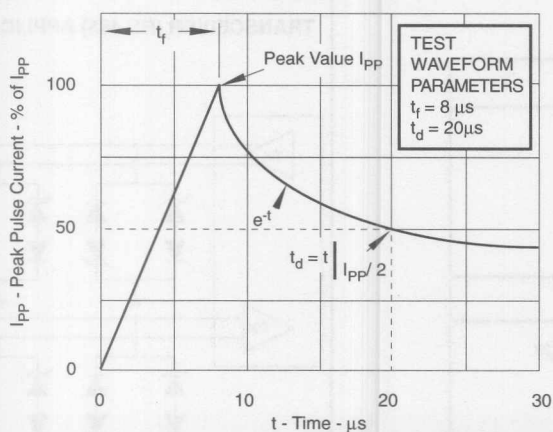
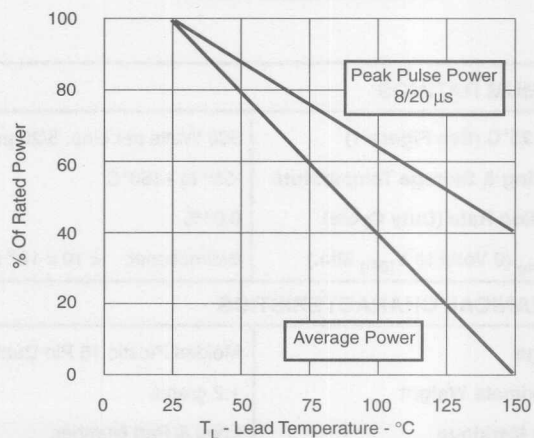


FIGURE 3
POWER DERATING CURVE



HIGH SPEED TVS DIODE ARRAY

APPLICATIONS

- RS-485, 100 Base T & Category 5 Data Lines
- Cellular Phones
- Network Interface Circuits: USB, ADSL, ISDN, FireWire, SCSI, ATM & Ethernet
- Digital I/O Ports

FEATURES

- Meets IEC 1000-4-2, -4 & -5 Industry Requirements
- 500 Watts Peak Pulse Power Dissipation (8/20 μ s)
- Available in 5 Voltage Types Ranging from 5.0V to 24V
- ESD Protection > 40 kilovolts
- Standard Dual-in-Line Package
- Low Capacitance
- 8 Line Bidirectional Multiple-diode Array
- UL 94V-0 Flammability Classification

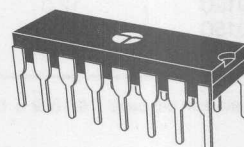
DESCRIPTION

This sixteen (16) pin bidirectional diode array family is a series of low capacitance, silicon transient voltage suppressors (TVS). The LCD was specifically designed for transient voltage suppression across signal or data lines at board level. These devices can be applied for use at the board interface or as protection for multiple IC components. The LCD series protects against the Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4, -5 and European Standard EN50082, EN61000-4 and EN300 386-2.

This series has a peak pulse power (P_{PP}) rating of 500 Watts for an 8/20 μ s waveshape. Typically, the LCD series can be used to protect combinations of 8 bidirectional signal lines on pin pairs (1 & 16), (2 & 15), (3 & 14), (4 & 13), (5 & 12), (6 & 11), (7 & 10) and (8 & 9). The LCD device contains eight (8) electrically isolated transient voltage suppressors; each consisting of two TVS diodes and two low capacitance diodes. There is no internal common ground.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	500 Watts per Line0, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded Plastic 16 Pin Dual-in-Line Package
Approximate Weight	1.2 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

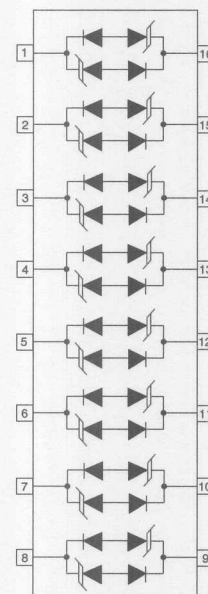
IEC 1000-4 COMPATIBLE



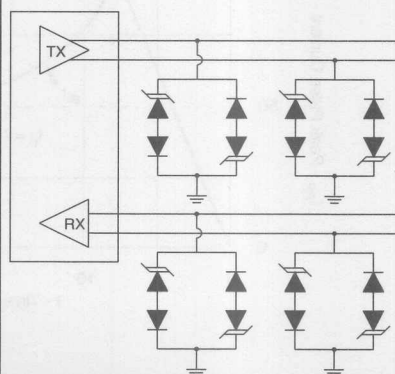
16 PIN PLASTIC DIP

CIRCUIT DIAGRAM

LCD05C
LCD08C
LCD12C
LCD15C
LCD24C



TRANSCEIVER (RS-485) APPLICATION



ELECTRICAL CHARACTERISTICS (Both directions) @ 25° C Ambient Temperature

PROTEK PART NUMBER	RATED STAND-OFF VOLTAGE (See Note 1) V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 10$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHZ C pF	TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
LCD05C	5.0	6.0	9.8	12.5	100	15	3
LCD08C	8.0	8.5	13.3	16.6	10	15	9
LCD12C	12.0	13.3	19.0	23.5	4	15	16
LCD15C	15.0	16.7	25.5	29.54	4	15	17
LCD24C	24.0	26.7	40.0	46.9	4	15	26

Note 1: Tested on pin pairs 1 & 16, 2 & 15, 3 & 14, 4 & 13, 5 & 12, 6 & 11, 7 & 10 and 8 & 9.

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

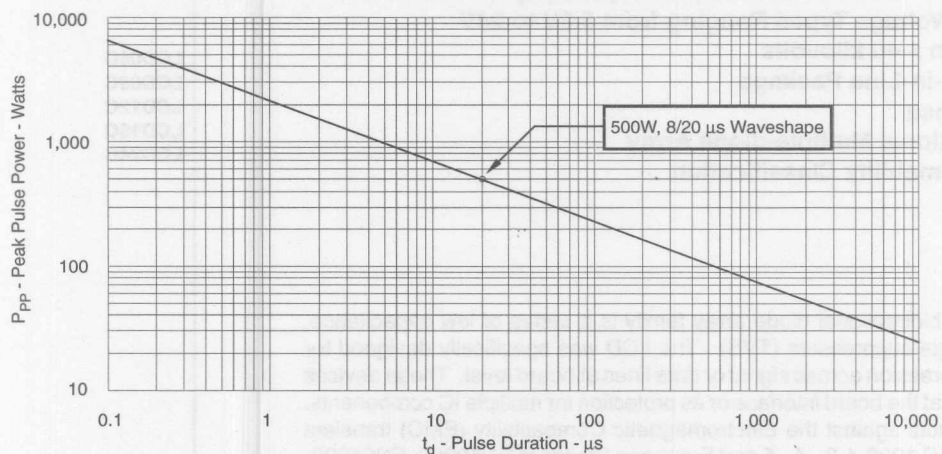


FIGURE 2
PULSE WAVE FORM

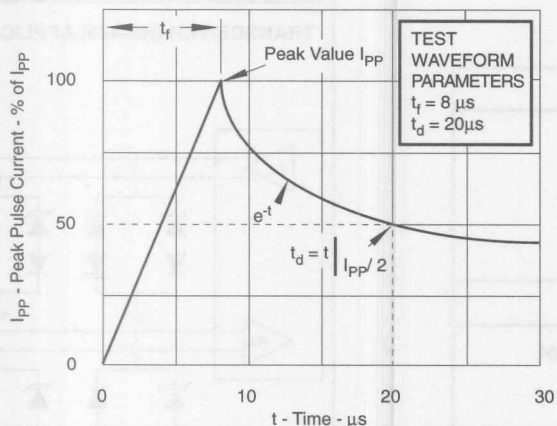
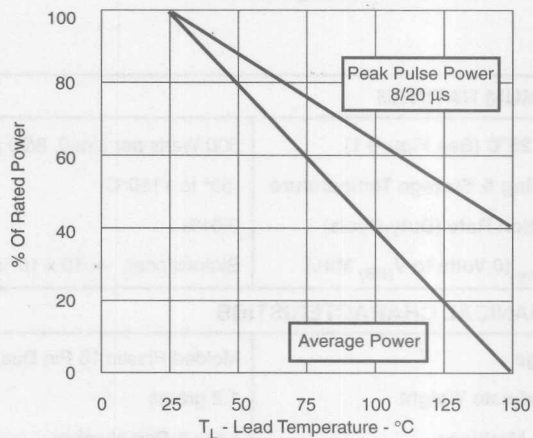


FIGURE 3
POWER DERATING CURVE



HIGH POWER/ HIGH SPEED TVS DIODE ARRAY

APPLICATIONS

- T1/E1 Line Cards
- Network Terminal Equipment
- ADSL, HSDL, USB, SCSI & WAN Interfaces
- ISDN Telecom Equipment
- Cellular Base Stations
- Data & Bus Line for FCC Part 68 Applications

FEATURES

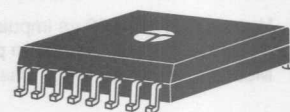
- 100A, 10/1000 μ s Waveshape per Bellcore GR-1089
- Meets IEC 1000-4-2, -4 & -5 Industry Requirements
- Low Clamping Voltage
- 200A for 10/160 μ s Impulse Waveshape, FCC Part 68
- 1,500 Watts Peak Pulse Power Dissipation (10/1000 μ s)
- ESD Protection > 40 kilovolts
- Low Capacitance for High Speed Data Lines
- UL 94V-0 Flammability Classification

DESCRIPTION

The PLC01-6 transient voltage suppressor (TVS) array is a high power, low capacitance data line protector that is designed to provide protection against ESD, tertiary lightning, and switching (logic level) transients. This device protects against Electromagnetic Compatibility (EMC) transient immunity standard IEC 1000-4-2, -4, -5, EN300 386-2 as well as FCC Part 68, 10/160 μ s impulse waveform. The PLC01-6 is typically used as a secondary protection element in T1/E1 line applications.

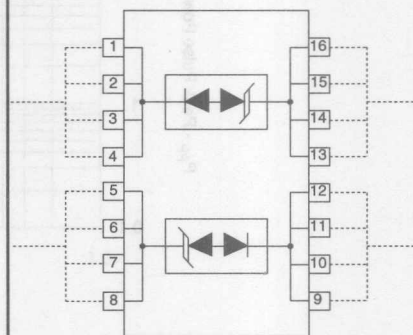
The PLC01-6 is packaged in an SO-16L, wide body plastic case designed with multiple, common leads for low package inductance. The two diode configurations are to be used in parallel for bidirectional applications or individually for two unidirectional data lines. If it is used for two unidirectional data lines, it is suggested that a rectifier diode (low capacitance, fast switching diode) be used in parallel with the TVS device to simulate a single unidirectional diode for circuit applications. A rectifier should be selected that will withstand a transient event in the forward direction.

IEC 1000-4 COMPATIBLE

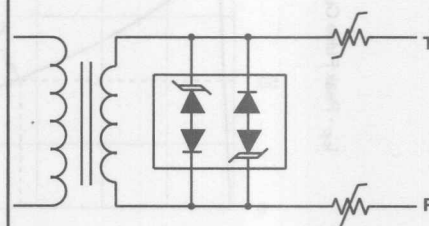


SO-16L PACKAGE

CIRCUIT DIAGRAM



TYPICAL LINE CARD APPLICATION (T1 & HDSL)



MAXIMUM RATINGS	
P_{pp} @ 25°C (See Figure 1)	1,500 Watts, 10/1000 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
t_{Clamping} (0 Volts to V_(BR) Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-16L Wide Body Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.5 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

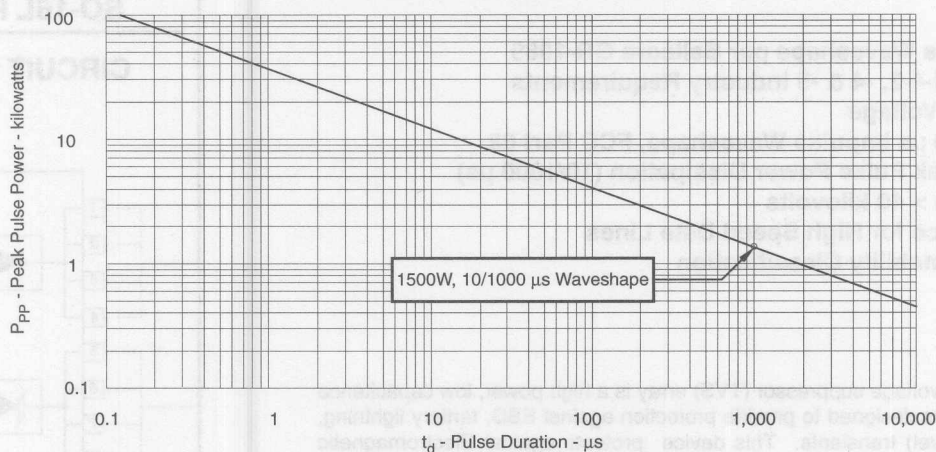
PROTEK PART NUMBER	RATED STAND-OFF VOLTAGE	MINIMUM BREAKDOWN VOLTAGE	MAXIMUM CLAMPING VOLTAGE (See Note 1) (See Fig. 2) @ $I_P = 100\text{ A}$ V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Note 2) (See Fig. 2) @ $I_P = 200\text{ A}$ V_C VOLTS	MAXIMUM LEAKAGE CURRENT	TYPICAL CAPACITANCE (See Note 3)
	V_{WM} VOLTS	@ 1 mA $V_{(BR)}$ VOLTS			@ V_{WM} I_D μA	@ 1 MHz C pF
PLC01-6	6.0	8.0	15.0	16.0	25	50

Note 1: V_C tested at 10/1000 μs impulse waveform.

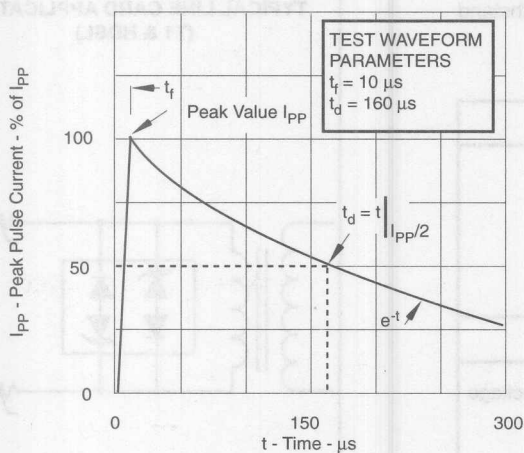
Note 2: 10/160 μs impulse waveform per Bellcore GR-1089.

Note 3: Measured with +6v to -6v bias (Bidirectional configuration only).

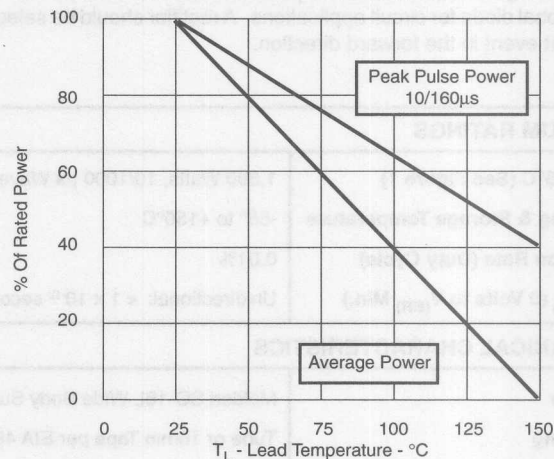
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVEFORM**



**FIGURE 3
POWER DERATING CURVE**



TELECOM DIODE BRIDGE/ TVS ARRAY

APPLICATIONS

- T1/E1 Line Cards
- ISDN U-Interfaces
- ADSL & HDSL Interfaces
- ISDN S/T Interfaces
- RS-485, 100 Base T & Category 5 Interface Circuits

FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- 750 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 40 kilovolts
- Low Capacitance - 25 pF
- 100A (2/10 μ s) per Bellcore 1089 (Intra-Building)
- UL 94V-0 Flammability Classification

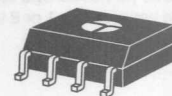
DESCRIPTION

The PLC03-6 is a low capacitance, surface mount, transient voltage suppressor (TVS) array, designed for the protection of telecommunication systems, I/O ports and data lines. With a peak pulse power (P_{PP}) rating of 750 Watts for an 8/20 μ s pulse, the PLC03-6 provides board level protection against ESD, EFT and induced lightning in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN300 386-2 immunity requirements.

The PLC03-6 is designed using a diode bridge configuration which provides low capacitance. This device can be used for bidirectional differential mode protection or unidirectional common mode protection. For bidirectional applications, pins 1 and 8 are connected to line 1 and pins 4 and 5 are connected to line 2. For unidirectional applications, pins 2, 3, 6, and 7 are connected to ground.

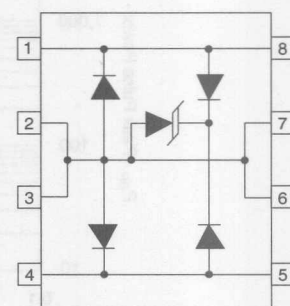
MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	750 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to V_{BR} Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

IEC 1000-4 COMPATIBLE

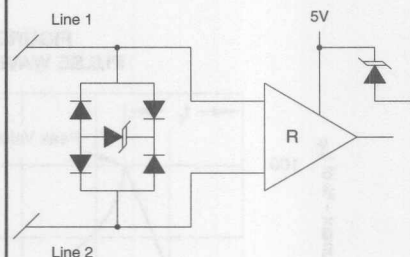


SO-8 PACKAGE

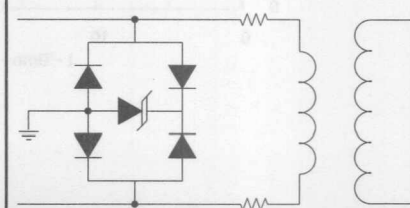
CIRCUIT DIAGRAM



HIGH SPEED LINE DRIVER/ RECEIVER PROTECTION



ISDN SECONDARY PROTECTION



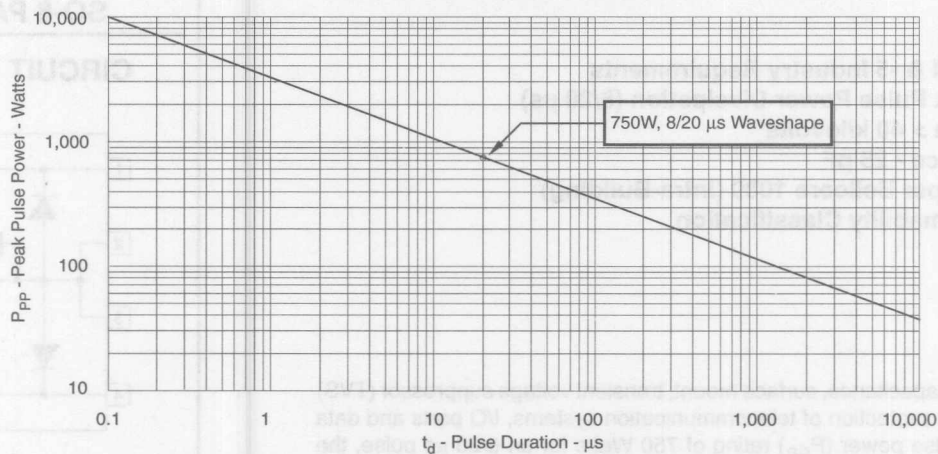
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE	MINIMUM BREAKDOWN VOLTAGE	MAXIMUM CLAMPING VOLTAGE (See Note 1)	MAXIMUM PEAK PULSE CURRENT (See Fig. 2)	MAXIMUM LEAKAGE CURRENT	TYPICAL CAPACITANCE	MAXIMUM CAPACITANCE (See Note 2)
		V_{WM} VOLTS	@ 1 mA $V_{(BR)}$ VOLTS	@ $I_p = 50$ A V_C VOLTS	I_{PP} AMPS	@ V_{WM} I_D μA	@ 0 V, 1 MHz C pF	@ 0 V, 1 MHz C pF
PLC03-6	PBA	6.0	6.8	15	50	25	18	25

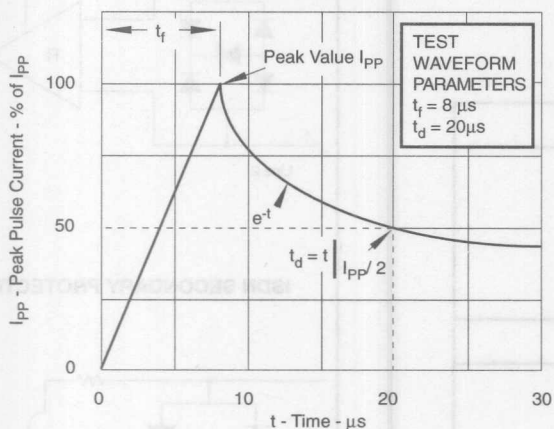
Note 1: For an 8/20 μs waveshape apply positive pulse to pin 1 or 8 to pin 2 or 3 (ground).

Note 2: Measure between pin 1 or 8 to pin 2 or 3; pin 1 or 8 to pin 4 or 5.

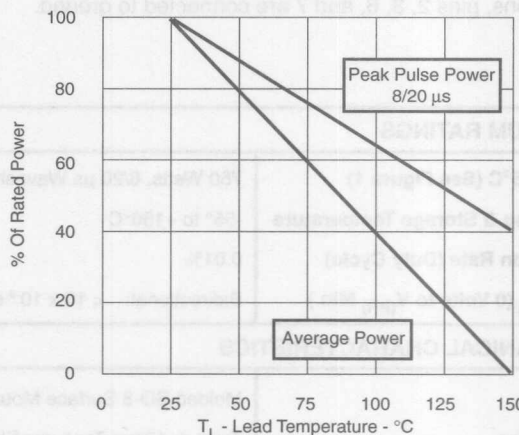
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



HIGH SPEED BIDIRECTIONAL TVS DIODE ARRAY

APPLICATIONS

- FireWire & RS-485 Data Lines
- Cellular Phone Terminals
- Portable Electronics
- Audio/ Video Inputs
- ADSL & HDSL Interfaces
- SCSI, ATM, USB & Ethernet Interfaces

FEATURES

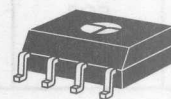
- IEC 1000-4-2, -4 & -5 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 40 kilovolts
- Available in 5 Voltage Types Ranging from 3.0V to 24V
- UL 94V-0 Flammability Classification
- Low Capacitance Protection for High Speed Data Lines

DESCRIPTION

The PLCDA is a low capacitance, bidirectional (See Circuit Diagram & Note 1), silicon transient voltage suppressor (TVS) array designed for use in applications with high frequency data lines. This series provides effective board level ESD and EFT protection for sensitive I/O ports, TTL and MOS bus lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082, EN61000-4 and EN300 386-2 immunity requirements.

The PLCDA series has a peak pulse power (P_{PP}) rating of 300 Watts for an 8/20 μ s pulse. These arrays can be used to protect two bidirectional lines.

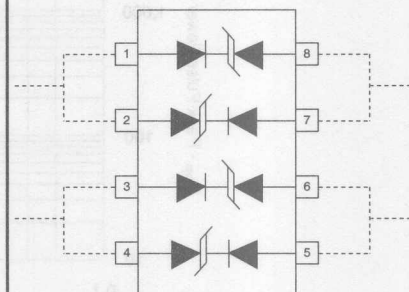
IEC 1000-4 COMPATIBLE



SO-8 PACKAGE

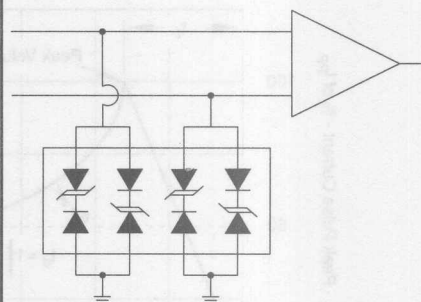
CIRCUIT DIAGRAM

PLCDA03
PLCDA05
PLCDA12
PLCDA15
PLCDA24



1. For bidirectional applications, connect external pins 1 & 2, 3 & 4, 5 & 6, and 7 & 8 as shown in the above circuit diagram.
2. Do not surge from pins 8 to 1, 2 to 7, 6 to 3, and 4 to 5. PIV typically greater than 100 Volts for each rectifier die.

TYPICAL DATA LINE APPLICATION



MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Device Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

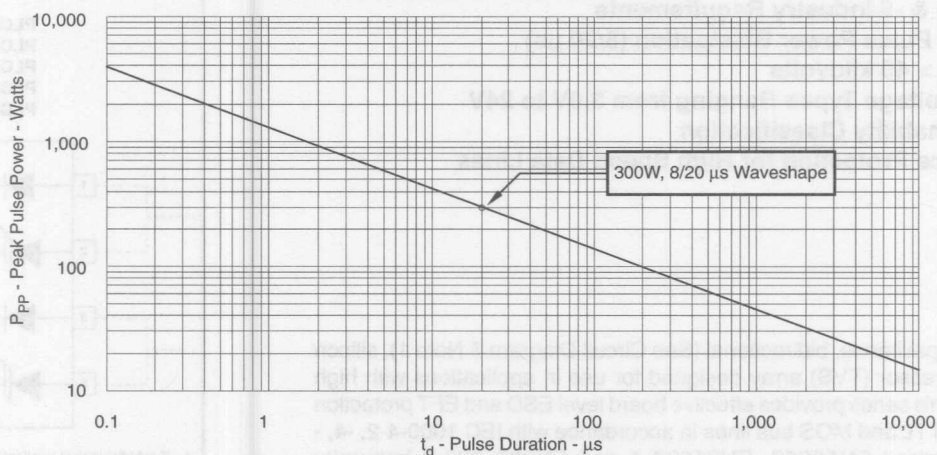
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1 & 2)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_p = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_p = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	TYPICAL CAPACITANCE @ 0 V, 1 MHz C pF	TEMPERATURE COEFFICIENT OF V_{BR} ΘV_{BR} mV/°C
PLCDA03	SGA	3.3	4.5	7.0	9.0	125	5	-2
PLCDA05	SGB	5.0	6.0	9.8	11	20	5	3
PLCDA12	SGC	12.0	13.3	19	24	1	5	16
PLCDA15	SGD	15.0	16.7	24	30	1	5	17
PLCDA24	SGE	24.0	26.7	43	55	1	5	22

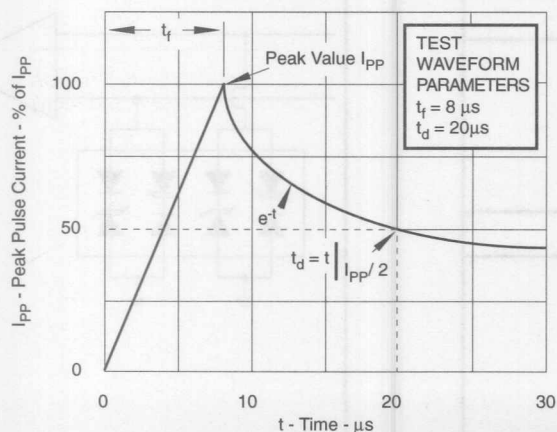
Note 1: Devices are designed to be used in parallel (See Circuit Diagram). For other applications, contact the factory. Do not apply surge in the "forward" direction of the TVS.

Note 2: Do not surge from pins 8 to 1, 2 to 7, 6 to 3, and 4 to 5. PIV typically greater than 100 Volts for each rectifier die. Electrical characteristics applies to pins 1 to 8, 7 to 2, 3 to 6, and 5 to 4.

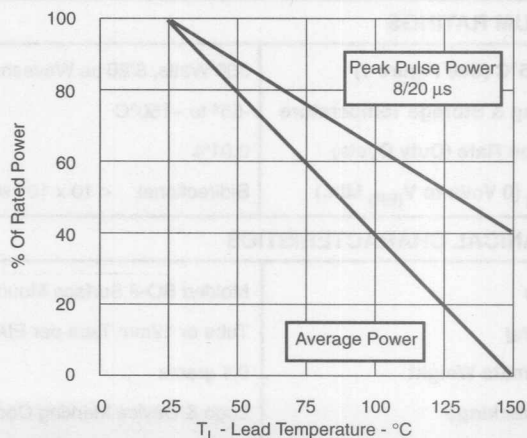
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



LOW CAPACITANCE TVS SOT 143

APPLICATIONS

- RS-485 & 100 Base T Data Lines
- USB, ATM & SCSI Interfaces
- Ethernet & FireWire
- Cellular Phones
- Audio/ Video Inputs
- Portable Electronics

FEATURES

- IEC 1000-4-2 & -4 Industry Requirements
- 175 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 25 kilovolts
- Low Capacitance - 10pF
- Available in 6 Voltage Types Ranging from 3.0V to 24V
- Standard SOT 143 Package
- Low Clamping Voltage
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSLC series are low capacitance, transient voltage suppressor (TVS) arrays, designed for high speed data line applications that provide protection against ESD, tertiary lightning and switching (logic level) transients. This series protects against Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082 and EN61000-4.

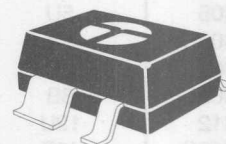
MAXIMUM RATINGS

P_{pp} @ 25°C (See Figure 1)	175 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
t_{Clamping} (0 Volts to V_(BR) Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds

MECHANICAL CHARACTERISTICS

Package	Molded JEDEC SOT-143 Surface Mount Package
Packaging	8mm Tape per EIA 481-1
Approximate Weight	10 milligrams
Device Markings	Marking Code
Miscellaneous	Pin No. 1 Indicated by larger lead

IEC 1000-4 COMPATIBLE

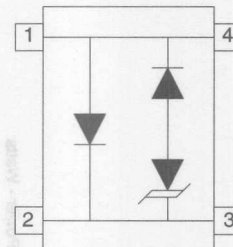


SOT-143 PACKAGE

CIRCUIT DIAGRAMS

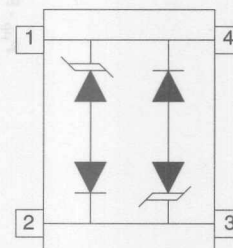
UNIDIRECTIONAL

PSLC03
PSLC05
PSLC08
PSLC12
PSLC15
PSLC24

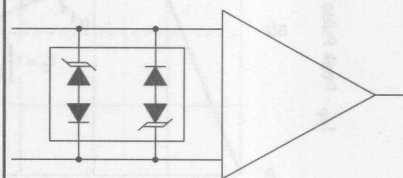


BIDIRECTIONAL

PSLC03C
PSLC05C
PSLC08C
PSLC12C
PSLC15C
PSLC24C



BALANCED LINE APPLICATION (Bidirectional Circuit)



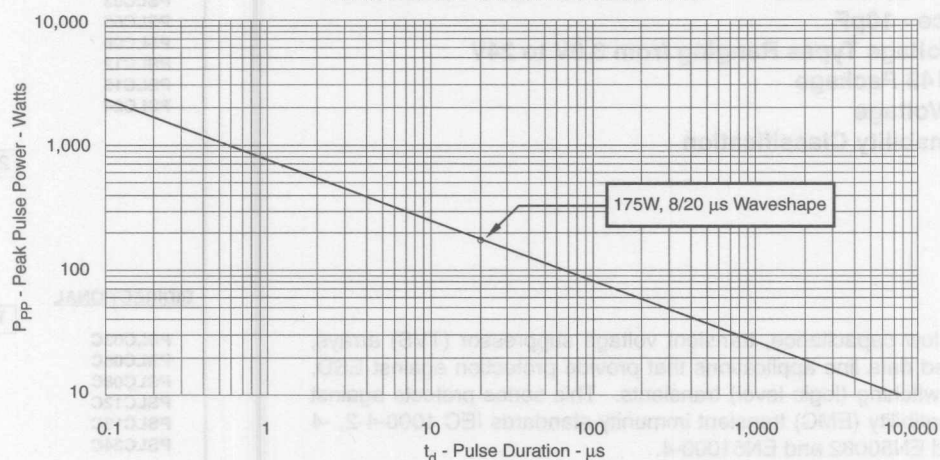
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1 & Note 2)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ 8/20 μ s I_{PP} AMPS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μ A	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
PSLC03	3U	3.3	4.0	9.0	20.0	125	10
PSLC03C	3B	3.3	4.0	9.0	20.0	125	10
PSLC05	5U	5.0	6.0	11.0	14.0	20	10
PSLC05C	5B	5.0	6.0	11.0	14.0	20	10
PSLC08	8U	8.0	8.5	16.6	10.0	10	10
PSLC08C	8B	8.0	8.5	16.6	10.0	10	10
PSLC12	12U	12.0	13.3	24.0	6.7	1	10
PSLC12C	12B	12.0	13.3	24.0	6.7	1	10
PSLC15	15U	15.0	16.6	30.0	5.3	1	10
PSLC15C	15B	15.0	16.6	30.0	5.3	1	10
PSLC24	24U	24.0	26.7	55.0 @ 3A	3.0	1	10
PSLC24C	24B	24.0	26.7	55.0 @ 3A	3.0	1	10

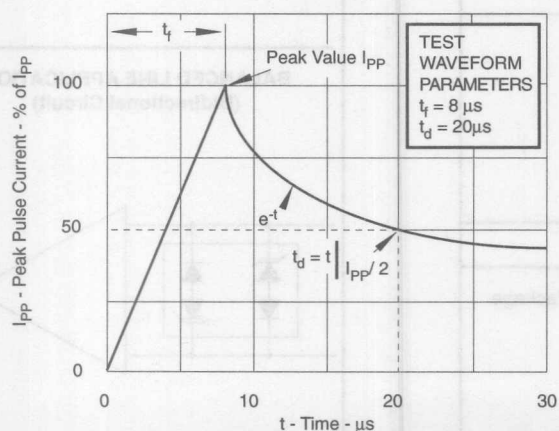
Note 1: For unidirectional devices, positive potential is applied from pin 2 to 1 or pin 3 to 4.

Note 2: Part numbers with a "C" suffix are bidirectional devices.

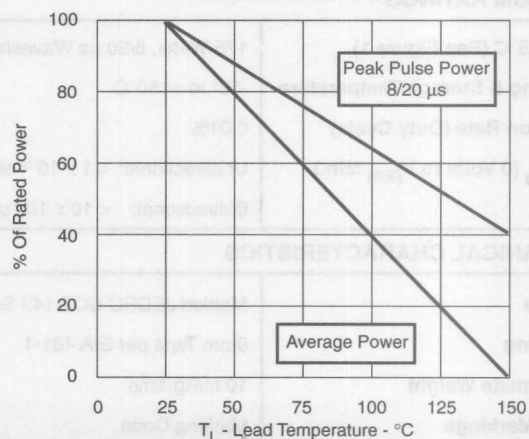
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



HIGH SPEED ASYMMETRICAL TVS ARRAY

APPLICATIONS

- RS-485 Transceivers
- Network Interfaces
- Wireless Systems
- Hand Held/Portable Electronics

FEATURES

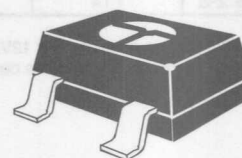
- IEC 1000-4-2, -4 & -5 Industry Requirements
- 400 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 25 kilovolts
- Standard SOT 23 Package
- Asymmetrical Data Line Protection
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSM712 transient voltage suppressor (TVS) arrays are designed for high speed asymmetrical data line applications, specifically RS-485. The 7 and 12 volt devices provide protection against ESD, EFT, tertiary lightning and switching (logic level) transients. The PSM712 protects against Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4.

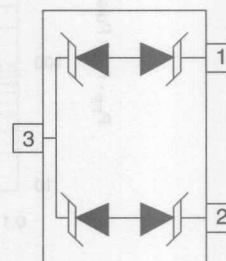
This device is offered in a SOT-23 package with a peak pulse power (P_{PP}) rating of 400 Watts for an 8/20 μ s pulse. The PSM712 can be used for two lines of protection.

IEC 1000-4 COMPATIBLE

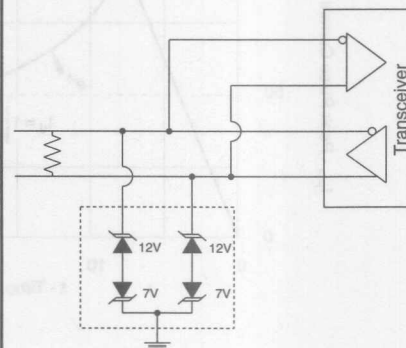


SOT-23 PACKAGE

CIRCUIT DIAGRAM



TYPICAL TRANSCEIVER APPLICATION



MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	400 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded JEDEC SOT-23 Surface Mount Package
Packaging	8mm Tape per EIA 481-1
Approximate Weight	10 milligrams
Device Markings	Marking Code

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1)	DEVICE MARKING CODE (See Note 2)	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 10$ A V_C VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ 8/20 μ s I_{PP} AMPS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μ A	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
Pin 3-1 & 3-2	712	7.0	7.5	11.0	14.0	15.0	20	75
Pin 1-3 & 2-3	712	12.0	13.3	19.0	24.0	15.0	1	75

Note 1: For 7V, pin 3 is positive. For 12V, pins 1 and 2 are positive.
Note 2: Marking code applies to same device.

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

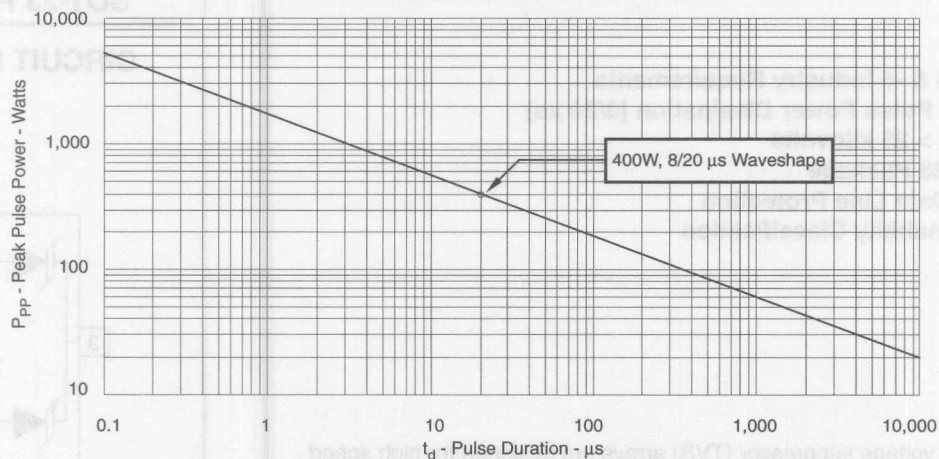


FIGURE 2
PULSE WAVE FORM

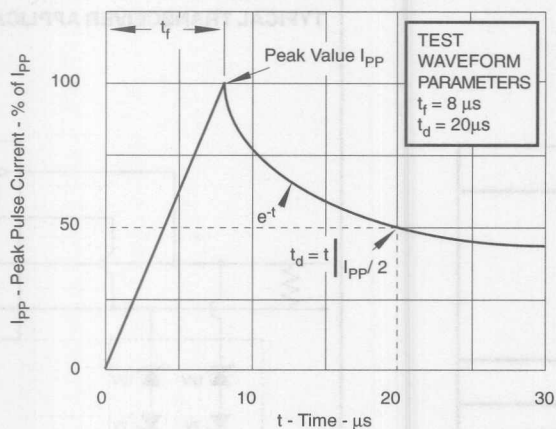
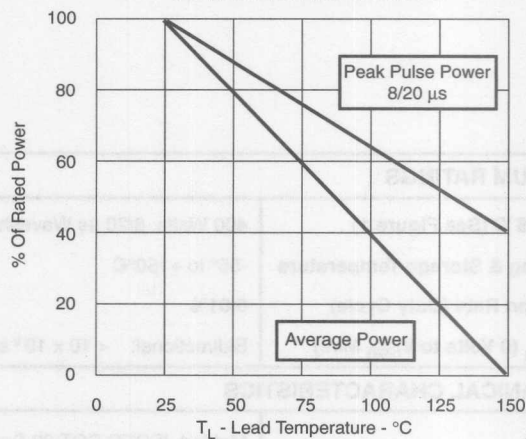


FIGURE 3
POWER DERATING CURVE



BIDIRECTIONAL MONOLITHIC TVS DIODE ARRAY

APPLICATIONS

- RS-232 & RS-423 Data Lines
- Cellular Phones
- Audio/ Video Inputs
- Portable Electronics
- Network Interfaces

FEATURES

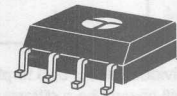
- IEC 1000-4-2, -4 & -5 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 40 kilovolts
- Available in 4 Voltage Types Ranging from 3.0V to 24V
- Bidirectional Monolithic Design
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSMDAxxC-4 is a monolithic, bidirectional, silicon transient voltage suppressor (TVS) array designed for use in applications which require multiple line protection where space is at a premium. In addition, this series can supply board level ESD and EFT protection to sensitive I/O ports, TTL and MOS bus lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4 immunity requirements.

This series is offered in a SO-8 surface mount package with a peak pulse power (P_{PP}) rating of 300 Watts for an 8/20 μ s pulse. These arrays can be used to protect a combination of four (4) bidirectional lines.

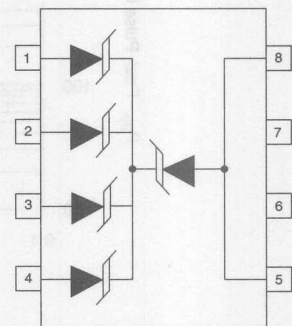
IEC 1000-4 COMPATIBLE



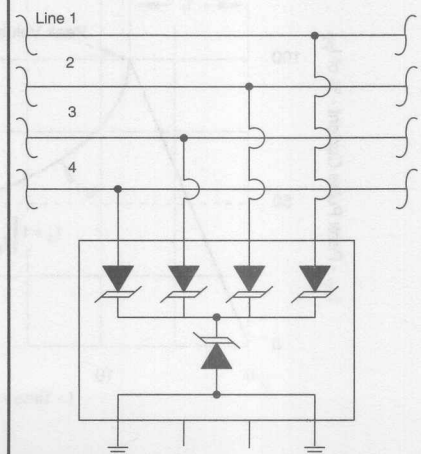
SO-8 PACKAGE

CIRCUIT DIAGRAM

PSMDA05C-4
PSMDA12C-4
PSMDA15C-4
PSMDA24C-4



TYPICAL DATA LINE APPLICATION



MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

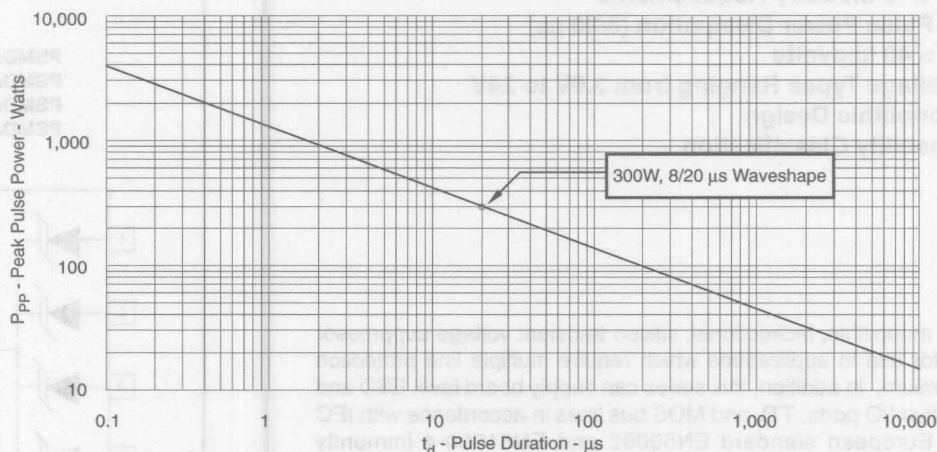
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE (See Note 2)	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	TYPICAL CAPACITANCE @ 0 V, 1 MHz C pF	MAXIMUM PEAK PULSE CURRENT I_{PPM} AMPS
PSMDA05C-4	TEB	5.0	6.0	9.8	11.0	100	350	20.0
PSMDA12C-4	TED	12.0	13.4	19.0	24.0	1	150	15.0
PSMDA15C-4	TEF	15.0	16.7	24.0	30.0	1	120	12.0
PSMDA24C-4	TEH	24.0	26.7	43.0	55.0	1	100	7.5

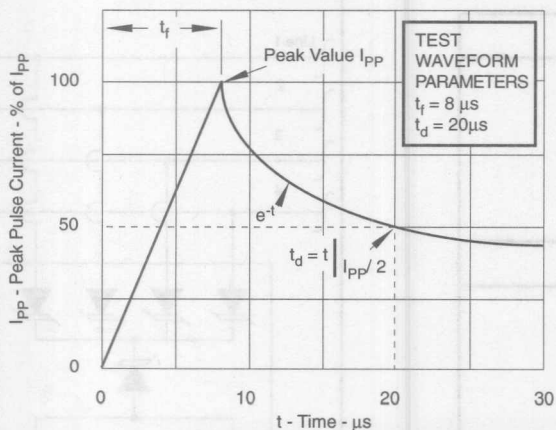
Note 1: Test individual pins 8 or 5 to pins 1, 2, 3, or 4. Pins 6 and 7 are open.

Note 2: There will always be a differential voltage of V_{WM} between any two data line pairs.

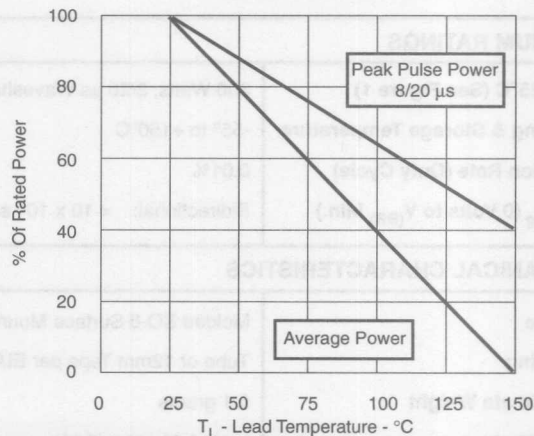
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



MULTIPLE LINE MONOLITHIC TVS DIODE ARRAY

APPLICATIONS

- RS-432, RS-422 & RS-423 Data Lines
- Microprocessor Based Equipment
- Controller & Monitoring Systems
- Portable Electronics

FEATURES

- IEC 1000-4-2 & -4 Industry Requirements
- 175 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 25 kilovolts
- Protects 5.0 Volt IC Components up to 6 Lines
- Up to 6 Unidirectional Lines and 5 Bidirectional Lines of Protection
- Low Clamping Voltage
- Monolithic Design
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSMDA05-6 is a 5.0 Volt, monolithic transient voltage suppressor (TVS) array designed to provide power line applications protection against ESD, tertiary lightning, and switching (logic level) transients. This device protects against the Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082 and EN61000-4.

This series is offered in a SO-8 surface mount package with a peak pulse power (P_{PP}) rating of 175 Watts for an 8/20 μ s pulse. These arrays offer low clamping voltage and can be used to protect sensitive IC components up to six unidirectional (6) and five bidirectional (5) lines.

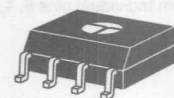
MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	175 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min)	Unidirectional: 1×10^{-12} seconds Bidirectional: 10×10^{-9} seconds

MECHANICAL CHARACTERISTICS

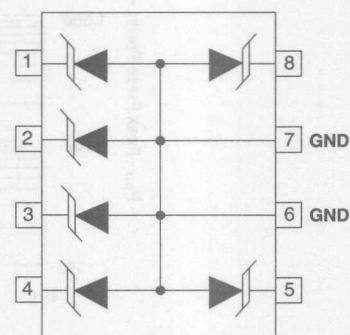
Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Common Ground Pins	6 & 7
Approximate Weight	0.1 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

IEC 1000-4 COMPATIBLE

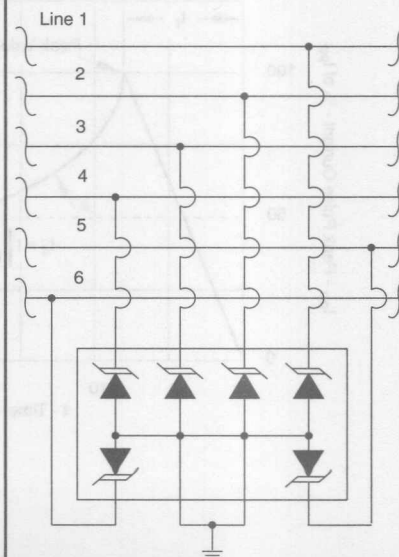


SO-8 PACKAGE

CIRCUIT DIAGRAM



TYPICAL DATA LINE APPLICATION



ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM FORWARD VOLTAGE @ 200 mA V_F VOLTS	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
PSMDA05-6	QEB	5.0	6.0	9.8	11.0	20	1.25	120

Note 1: Test from individual pins 8, 1, 2, 3, 4 and 5 to ground pins 6 and 7 (Unidirectional Only).

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

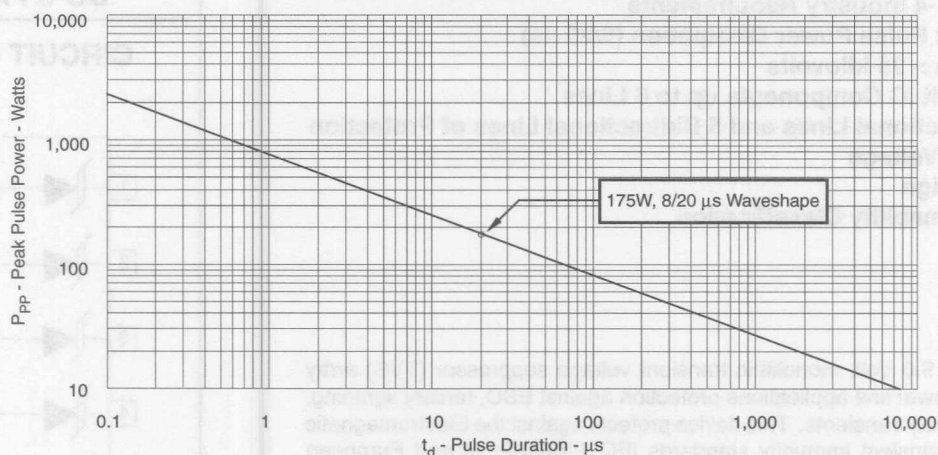


FIGURE 2
PULSE WAVE FORM

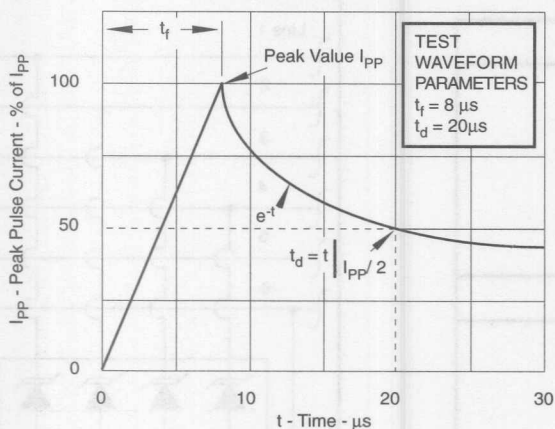
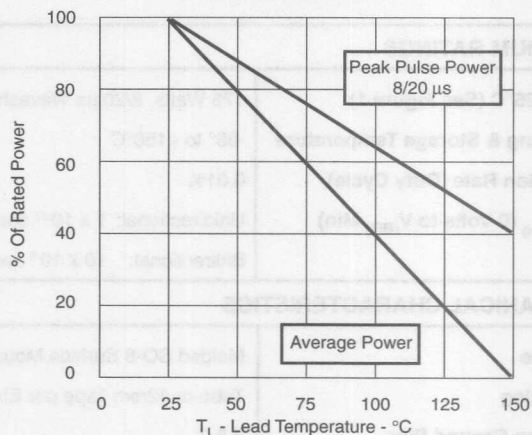


FIGURE 3
POWER DERATING CURVE



BIDIRECTIONAL MONOLITHIC TVS DIODE ARRAY

APPLICATIONS

- Multiple I/O Port Protection
- Board Level Interface Connection
- RS-232, RS-422 & RS-423
- Portable Electronics

FEATURES

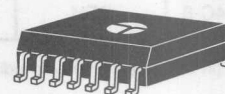
- IEC 1000-4-2, -4 & -5 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation (8/20 μ s)
- 2,500 Watts Peak Pulse Power Dissipation per Package
- ESD Protection > 40 kilovolts
- Available in 4 Voltage Types Ranging from 5.0V to 24V
- 8 Bidirectional Lines (Monolithic Design)
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSMDAxxC-8 is a monolithic, bidirectional silicon transient voltage suppressor (TVS) array designed for use in applications which require multiple line protection where space is at a premium. This series can supply board level ESD and EFT protection to sensitive I/O ports, TTL and MOS bus lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4.

The PSMDAxxC-8 series is offered in an SO-14 surface mount package with a peak pulse power (P_{PP}) rating of 300 Watts for an 8/20 μ s waveshape and 2,500 Watts P_{PP} per package for an 8/20 μ s waveshape. These arrays can be used to protect a combination of eight (8) bidirectional lines.

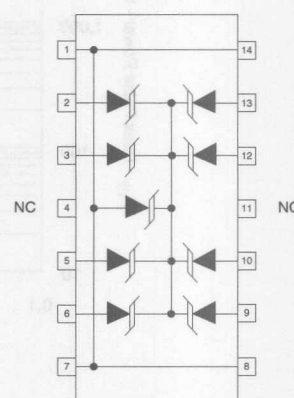
IEC 1000-4 COMPATIBLE



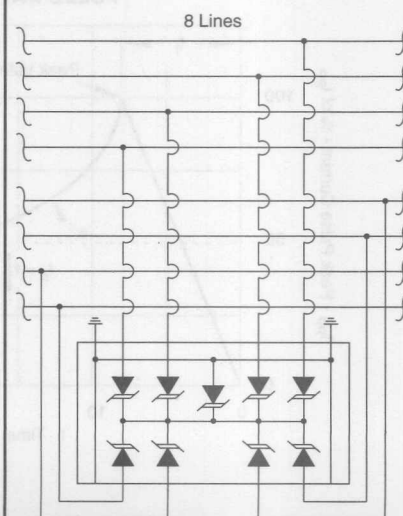
SO-14 PACKAGE

CIRCUIT DIAGRAM

PSMDA05C-8
PSMDA12C-8
PSMDA15C-8
PSMDA24C-8



TYPICAL DATA LINE APPLICATION



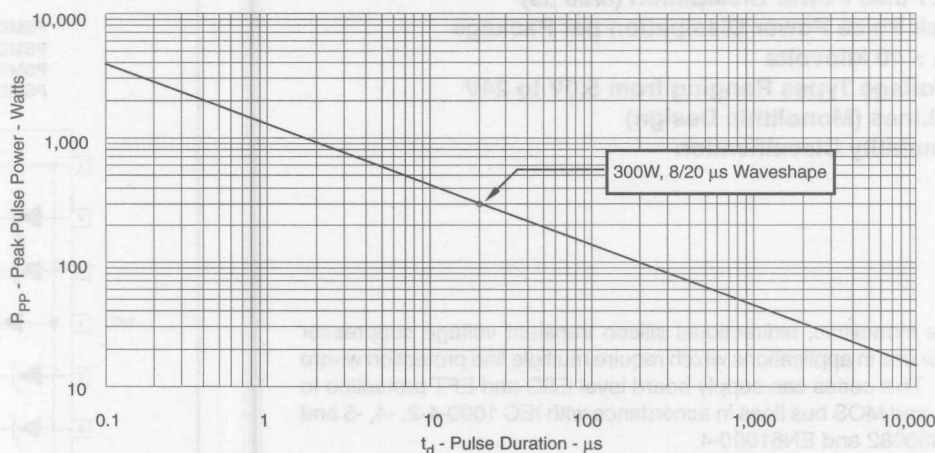
MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-14 Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Common Ground Pins	1, 7, 8 & 14
Approximate Weight	0.15 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

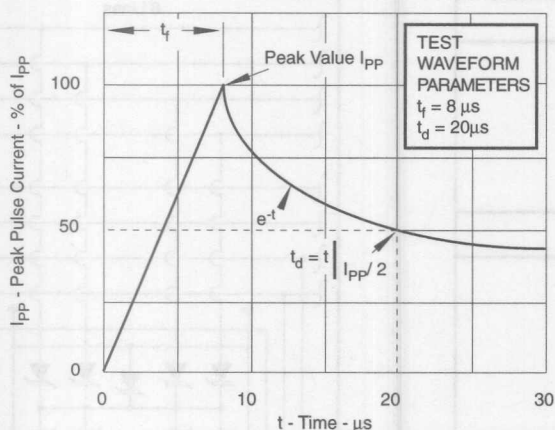
PROTEK PART NUMBER (See Note 1)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) I_{PP} AMPS	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
PSMDA05C-8	SEB	5.0	6.0	9.8	11	100	20.0	350
PSMDA12C-8	SED	12.0	13.4	19	24	1	15.0	150
PSMDA15C-8	SEF	15.0	16.7	24	30	1	12.0	120
PSMDA24C-8	SEH	24.0	26.7	43	55	1	7.5	100

Note 1: Test (in both directions) from individual pins: 2, 3, 5, 6, 9, 10, 12, 13 to common pins 1 or 7 or 8 or 14.

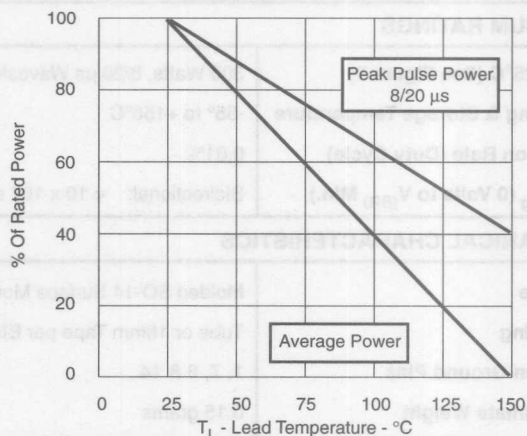
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



UNIDIRECTIONAL MONOLITHIC TVS DIODE ARRAY

APPLICATIONS

- Multiple I/O Port Protection
- Board Level Interface Connection
- RS-232, RS-422 & RS-423 Data Lines
- Portable Electronics

FEATURES

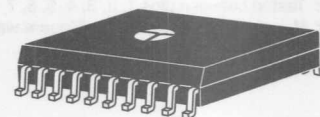
- IEC 1000-4-2 & -4 Industry Requirements
- 175 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 25 kilovolts
- Protects 5.0 Volt IC Components up to 18 Lines
- Unidirectional Monolithic Design
- Low Clamping Voltage
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSMDA05-18 is a 5.0 Volt unidirectional, eighteen (18) line, monolithic transient voltage suppressor (TVS) array designed to provide power line applications protection against ESD, tertiary lightning, and switching (logic level) transients. This device protects against the Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082 and EN61000-4.

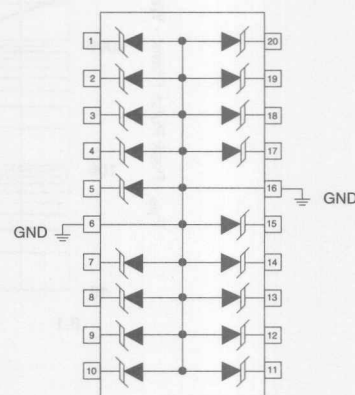
This device is offered in an SO-20L wide body surface mount package with a peak pulse power (P_{PP}) rating of 175 Watts for an 8/20 μ s pulse. This array offers low clamping voltage and can be used to protect sensitive IC components up to eighteen unidirectional (18) lines.

IEC 1000-4 COMPATIBLE

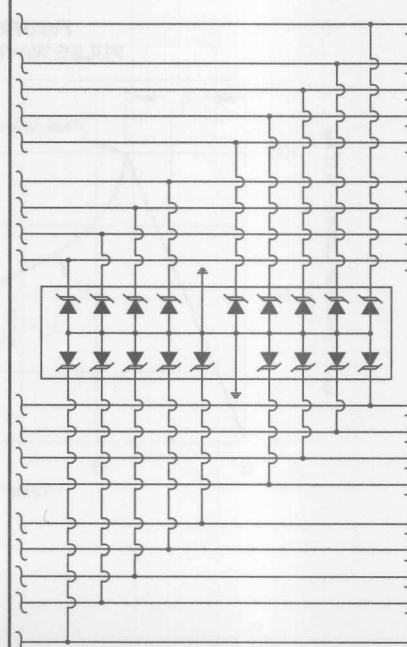


SO-20L PACKAGE

CIRCUIT DIAGRAM



DC DATALINE APPLICATION



MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	175 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds

MECHANICAL CHARACTERISTICS

Package	Molded SO-20L Wide Body Surface Mount Package
Packaging	Tube or 24mm Tape per EIA 481
Common Ground Pins	Pin Nos. 6 & 16
Approximate Weight	0.6 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

NUMBER (See Note 1)	CODE	VOLTAGE (See Note 2) V_{WM} VOLTS	VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	CURRENT @ V_{WM} I_D μA	CURRENT @ 200 mA V_F VOLTS	@ 0V, 1 MHz C pF
PSMDA05-18	VEB	5.0	6.0	9.8	11	20	1.25	120

Note 1: Tested between pins 1, 2, 3, 4, 5, 8, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 & 20 and common pins 6 & 16 (unidirectional only).

Note 2: $V_F = 1.5V$ @ 50mA, 300 μs (Square wave).

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

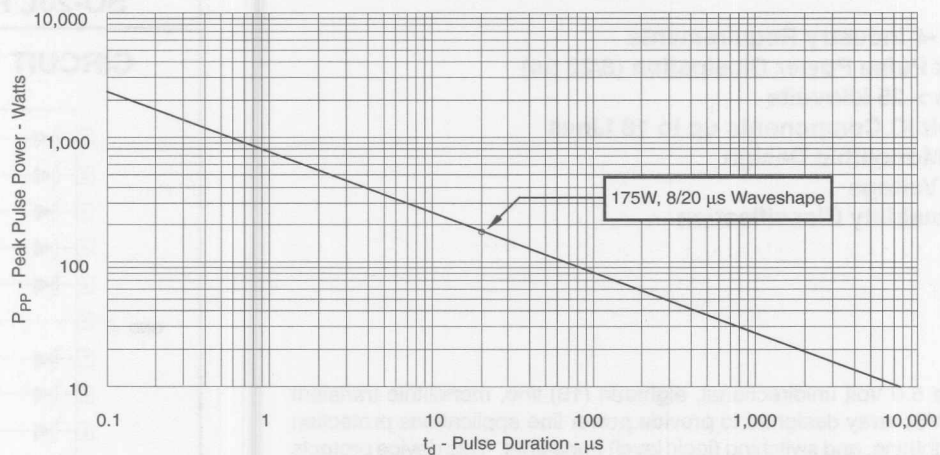


FIGURE 2
PULSE WAVE FORM

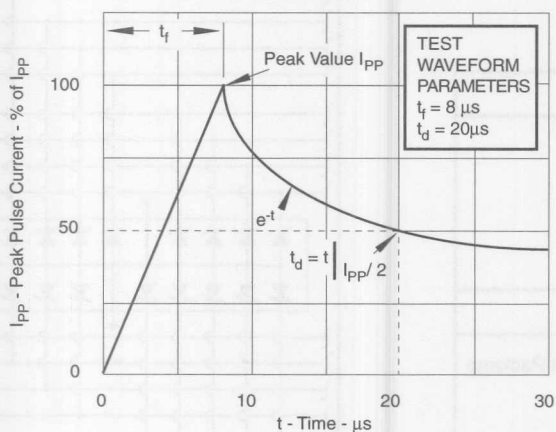
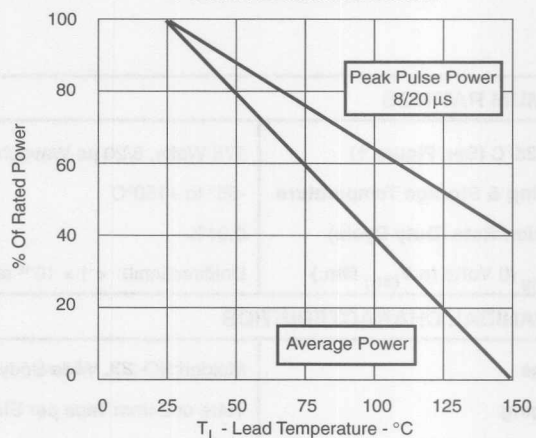


FIGURE 3
POWER DERATING CURVE



MULTIPLE LINE MONOLITHIC TVS ARRAY

APPLICATIONS

- Microprocessor Based Equipment
- Audio/Video Inputs
- RS-232 & RS-423 Data Lines
- Portable Electronics
- Network Interface
- Cellular Phones

FEATURES

- IEC 1000-4-2 & -4 Industry Requirements
- 175 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 25 kilovolts
- Low Clamping Voltage
- Standard SOT-23-6 Package
- Up to Four (4) Unidirectional Lines of Protection
- Available in 4 Voltage Types Ranging from 5.0V to 24V
- UL 94V-0 Flammability Classification

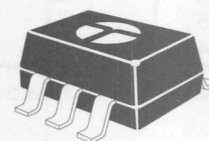
DESCRIPTION

The PSMS family is a series of silicon, monolithic, transient voltage suppressor (TVS) arrays designed to protect data and transmission line applications from the effects of ESD, EFT and induced lightning. This series protects against Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082 and EN61000-4.

The PSMS series offers low clamping voltage for the protection of sensitive CMOS, BiCMOS, HCMOS and HSIC components. This series has a peak pulse power (P_{PP}) rating of 175 Watts for an 8/20 μ s waveshape. The PSMS series is available in SOT-23, 6 lead package which allows the user to protect up to four unidirectional lines.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	175 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1×10^{-12} seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SOT-23, 6 Lead Package
Packaging	8mm Tape per EIA 481-1
Common Ground Pins	2 & 5
Approximate Weight	0.6 grams
Device Markings	Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

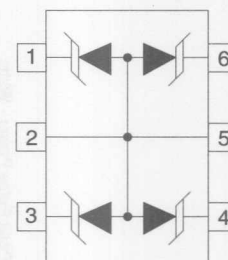
IEC 1000-4 COMPATIBLE



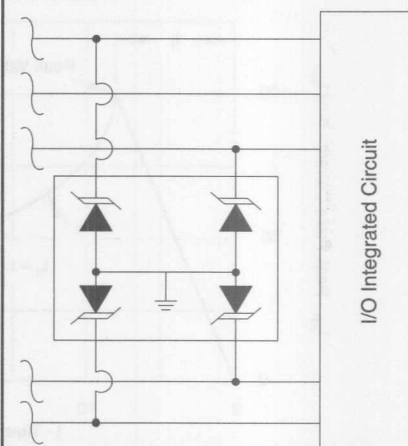
SOT-23-6 PACKAGE

CIRCUIT DIAGRAMS

PSMS05
PSMS12
PSMS15
PSMS24



TYPICAL TRANSCEIVER PROTECTION APPLICATION

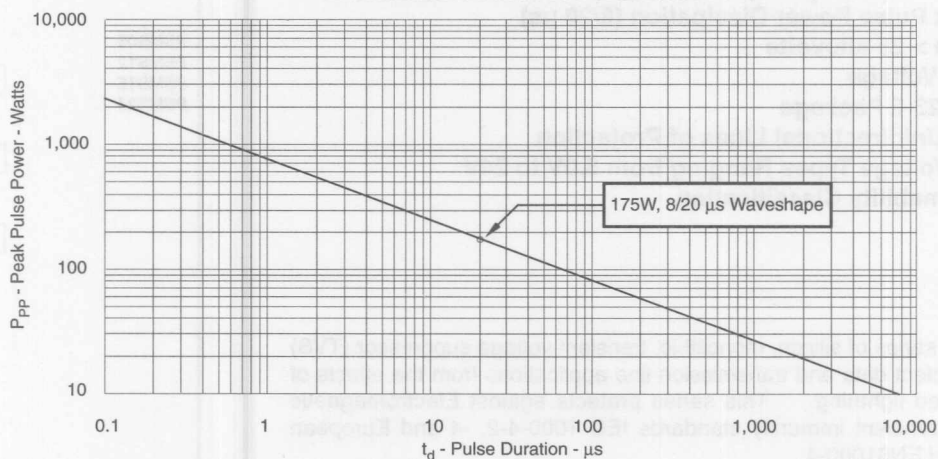


ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

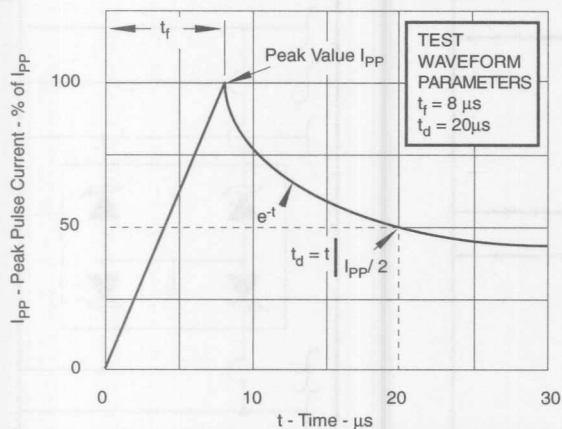
PROTEK PART NUMBER	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE (See Note 1) @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ 8/20 μs I_{PP} AMPS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
PSMS05	PRH	5.0	6.0	9.8	17	20	400
PSMS12	PRI	12.0	13.3	19	12	1	150
PSMS15	PRJ	15.0	16.7	24	10	1	100
PSMS24	PRK	24.0	26.7	43	5	1	60

Note 1: Test between pins 1 to 2 or 5, 3 to 2 or 5, 4 to 2 or 5, 6 to 2 or 5.

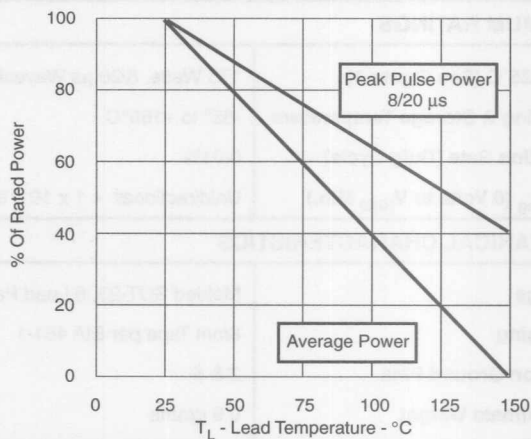
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



MULTIPLE LINE MONOLITHIC TVS ARRAY

TVS
Arrays

APPLICATIONS

- Microprocessor Based Equipment
- Audio/Video Inputs
- RS-232 & RS-423 Data Lines
- Portable Electronics
- Network Interface
- Cellular Phones

FEATURES

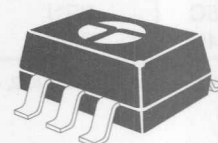
- IEC 1000-4-2 & -4 Industry Requirements
- 175 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 25 kilovolts
- Low Clamping Voltage
- Standard SOT-23-6 Package
- Up to Five (5) Unidirectional Lines of Protection, Four (4) Bidirectional
- Available in 4 Voltage Types Ranging from 5.0V to 24V
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSMSxxC family is a series of silicon, monolithic, transient voltage suppressor (TVS) arrays designed to protect data and transmission line applications from the effects of ESD, EFT and induced lightning. This series protects against Electromagnetic Computability (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082 and EN61000-4.

The PSMSxxC series offers low clamping voltage for the protection of sensitive CMOS, BiCMOS, HCMOS and HSIC components. This series has a peak pulse power (P_{PP}) rating of 175 Watts for an 8/20 μ s waveshape. The PSMSxxC series is available in SOT-23, 6 lead package which allows the user to protect up to five unidirectional and 4 bidirectional lines.

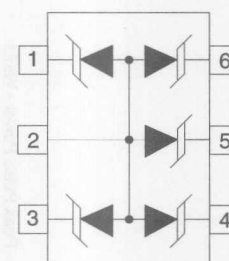
IEC 1000-4 COMPATIBLE



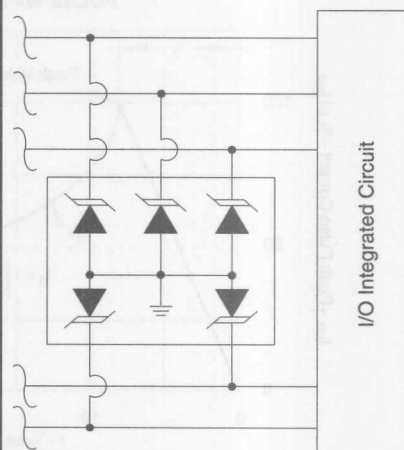
SOT-23-6 PACKAGE

CIRCUIT DIAGRAM

PSMS05C
PSMS12C
PSMS15C
PSMS24C



TYPICAL TRANSCEIVER PROTECTION APPLICATION



MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	175 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds

MECHANICAL CHARACTERISTICS

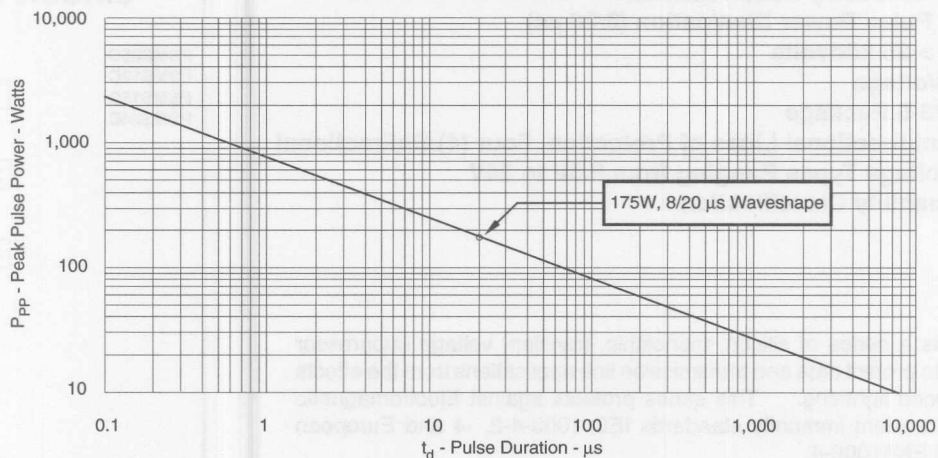
Package	Molded SOT-23, 6 Lead Package
Packaging	8mm Tape per EIA 48-1
Approximate Weight	0.6 grams
Device Markings	Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

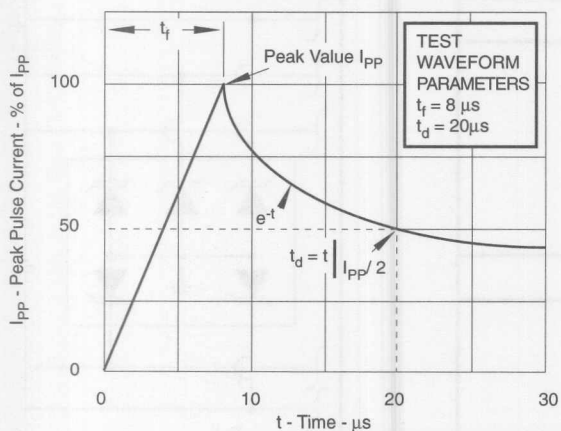
PROTEK PART NUMBER	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE (See Note 1) @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ 8/20 μs I_{PP} AMPS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
PSMS05C	PRL	5.0	6.0	9.8	17	20	400
PSMS12C	PRM	12.0	13.3	19	12	1	150
PSMS15C	PRN	15.0	16.7	24	10	1	100
PSMS24C	PRO	24.0	26.7	43	5	1	60

Note 1: Test between pins 1 to 2, 3 to 2, 4 to 2, 5 to 2 and 6 to 2.

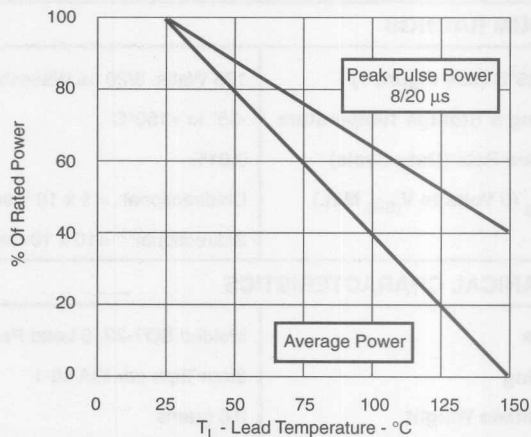
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



APPLICATIONS

- RS-232, RS-422 & RS-423 Data Lines
- Cellular Phones
- Controller & Monitoring Systems
- Portable Electronics
- Wireless Bus Protection

FEATURES

- IEC 1000-4-2 & -4 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 40 kilovolts
- Available in 7 Voltage Types Ranging from 3.0V to 36V
- Standard SOT-23 Package
- Low Clamping Voltage
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSOT series are transient voltage suppressor (TVS) arrays, designed for individual power or data line applications that provide protection against ESD, tertiary lightning and switching (logic level) transients. This series protects against international Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082 and EN61000-4.

The PSOT series offers low clamping voltage for the protection of sensitive CMOS, BiCMOS, HCMOS and HSIC components. This series has a peak pulse power (P_{PP}) rating of 300 Watts for an 8/20 μ s waveshape. The PSOT series is available in either single or dual junction configurations. The dual junction configuration (part numbers with a "C" suffix) has a common anode pin (3) for two separate unidirectional lines, or a single bidirectional line for signal or data line protection (pins 1 to 2).

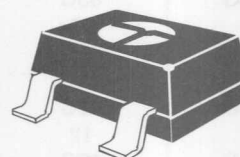
MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Forward Surge Rating	10A, 1/120 seconds @ 25°C (Unidirectional Only)
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds

MECHANICAL CHARACTERISTICS

Package	Molded JEDEC SOT-23 Surface Mount Package
Packaging	8mm Tape per EIA 481-1
Approximate Weight	10 milligrams
Device Markings	Marking Code

IEC 1000-4 COMPATIBLE

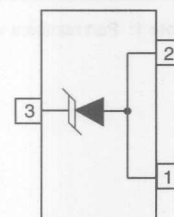


SOT-23 PACKAGE

CIRCUIT DIAGRAMS

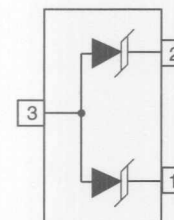
UNIDIRECTIONAL

PSOT03
PSOT05
PSOT08
PSOT12
PSOT15
PSOT24
PSOT36

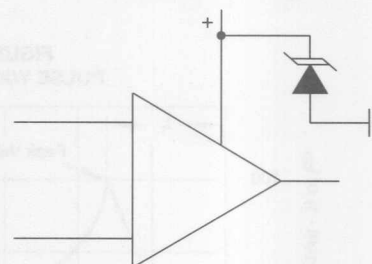


BIDIRECTIONAL

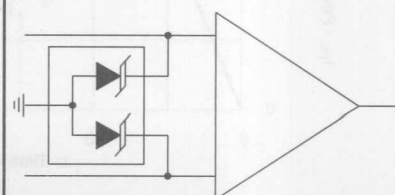
PSOT03C
PSOT05C
PSOT08C
PSOT12C
PSOT15C
PSOT24C
PSOT36C



SUPPLY VOLTAGE (V_{CC})



BALANCED DATALINES

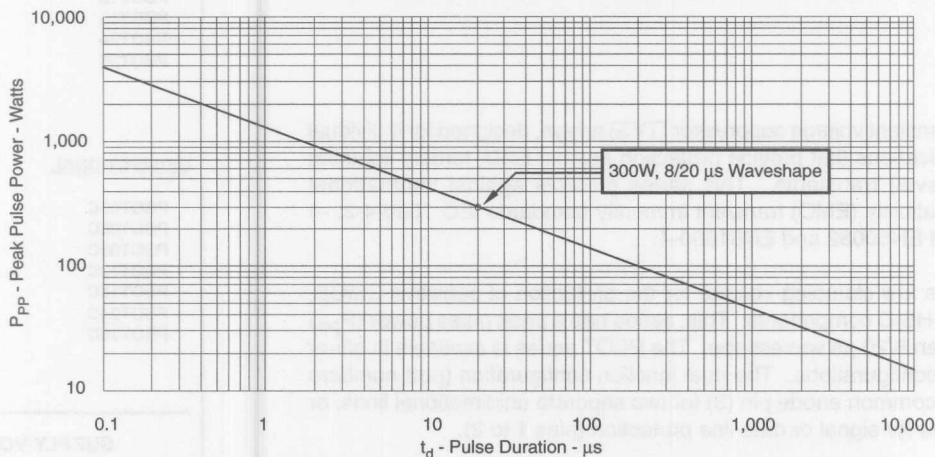


ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

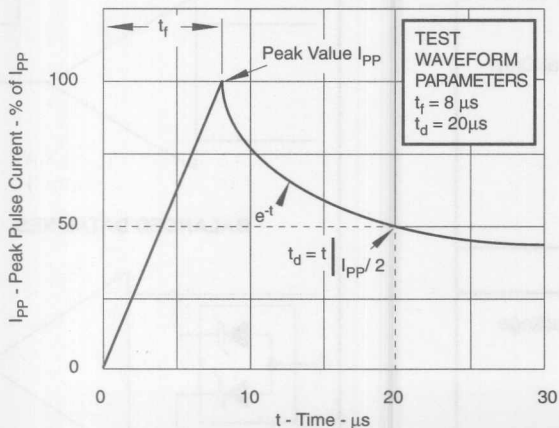
PROTEK PART NUMBER (See Note 1)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
PSOT03	03	3.3	4.0	6.5	7.5	125	800
PSOT03C	03C	3.3	4.5	7.0	9.0	125	600
PSOT05	05	5.0	6.0	9.8	12.5	100	550
PSOT05C	05C	5.0	6.0	9.8	12.5	100	400
PSOT08	08	8.0	8.5	13.4	15.0	10	400
PSOT08C	08C	8.0	8.5	13.4	15.0	10	350
PSOT12	12	12.0	13.3	19.0	28.0	2	185
PSOT12C	12C	12.0	13.3	19.0	28.0	2	150
PSOT15	15	15.0	16.7	24.0	35.0	1	140
PSOT15C	15C	15.0	16.7	24.0	35.0	1	100
PSOT24	24	24.0	26.7	43.0	60.0	1	88
PSOT24C	24C	24.0	26.7	43.0	60.0	1	63
PSOT36	36	36.0	40	60.0	75.0	1	80
PSOT36C	36C	36.0	40	60.0	75.0	1	60

Note 1: Part numbers with a "C" suffix are bidirectional devices (dual junction).

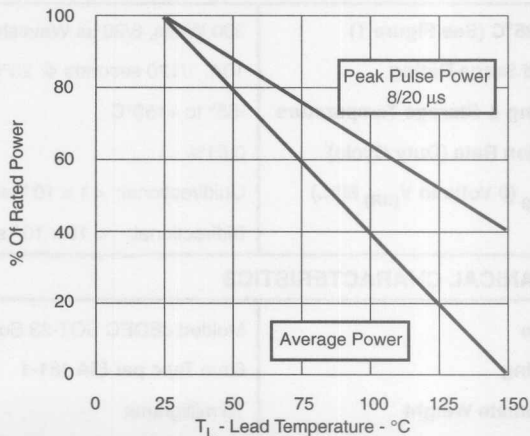
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



LOW CAPACITANCE TVS SOT-23

APPLICATIONS

- RS-485 & 100 Base T Data Lines
- USB, ATM & SCSI Interfaces
- Ethernet & FireWire
- Cellular Phones
- Audio/ Video Inputs
- Portable Electronics

FEATURES

- IEC 1000-4-2 & -4 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 40 kilovolts
- Low Capacitance - 5 pF
- Available in 6 Voltage Types Ranging from 3.0V to 24V
- Standard SOT-23 Package
- Low Clamping Voltage & Low Capacitance
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSOTxxLC series are unidirectional, low capacitance, transient voltage suppressor (TVS) arrays, designed for high speed data line applications that provide protection against ESD, tertiary lightning and switching (logic level) transients. This series protects against Electromagnetic Compatibility (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082 and EN61000-4.

The PSOTxxLC series offers low clamping voltage for the protection of sensitive CMOS, BiCMOS, HCMOS and HSIC components. This series has a peak pulse power (P_{PP}) rating of 300 Watts for an 8/20 μ s waveshape. The PSOTxxLC is constructed using a single TVS diode in series with a compensating diode for low capacitance. The PSOTxxLC series are unidirectional, low capacitance devices which can be used in parallel, opposite polarity with another PSOTxxLC device for bidirectional applications or with a rectifier diode (low capacitance, fast switching diode) of opposite polarity for unidirectional applications.

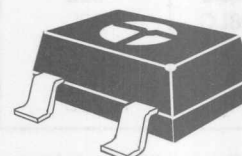
MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds (from pins 1-2)

MECHANICAL CHARACTERISTICS

Package	Molded JEDEC SOT-23 Surface Mount Package
Packaging	8mm Tape per EIA 481-1
Approximate Weight	10 milligrams
Device Markings	Marking Code

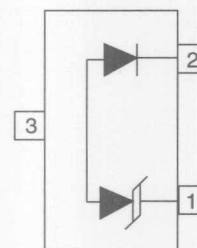
IEC 1000-4 COMPATIBLE



SOT-23 PACKAGE

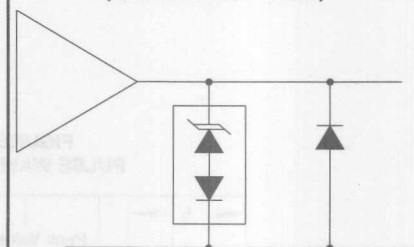
CIRCUIT DIAGRAM

PSOT03LC
PSOT05LC
PSOT08LC
PSOT12LC
PSOT15LC
PSOT24LC

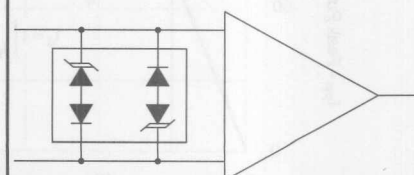


Note 1: Test between pins 1 and 2. Positive potential is applied to pin 1, pin 2 is connected to ground and pin 3 is open.

UNBALANCED LINE APPLICATION (Unidirectional Circuit)



BALANCED LINE APPLICATION (Bidirectional Circuit)



TVS
Arrays

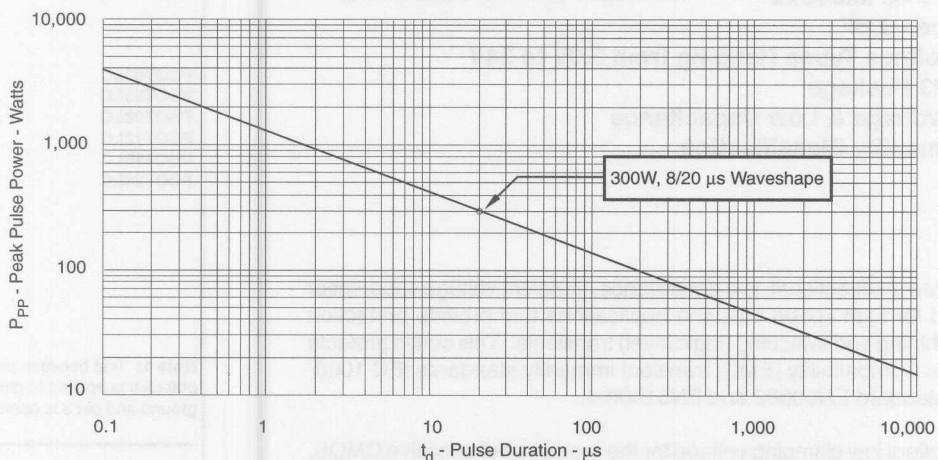
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE (See Note 2) @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
PSOT03LC	03L	3.3	4.0	7.0	9.0	125	5
PSOT05LC	05L	5.0	6.0	9.8	11.0	20	5
PSOT08LC	08L	8.0	8.5	13.4	16.6	10	5
PSOT12LC	12L	12.0	13.3	19.0	24.0	1	5
PSOT15LC	15L	15.0	16.7	24.0	30.0	1	5
PSOT24LC	24L	24.0	26.7	43.0	55.0	1	5

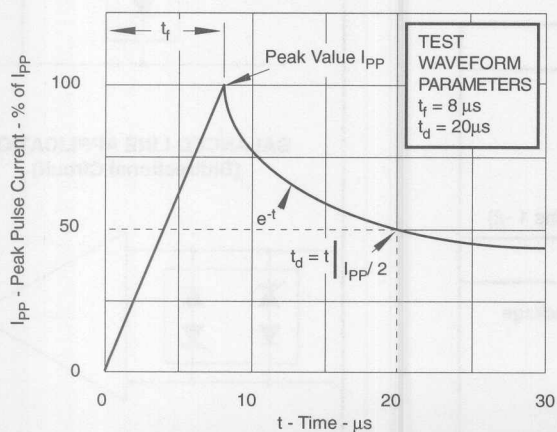
Note 1: Positive potential is applied from pin 1 to 2, pin 2 is ground.

Note 2: Do not test or surge from pin 2 to 1. PIV typically greater than 100 Volts for the rectifier diode.

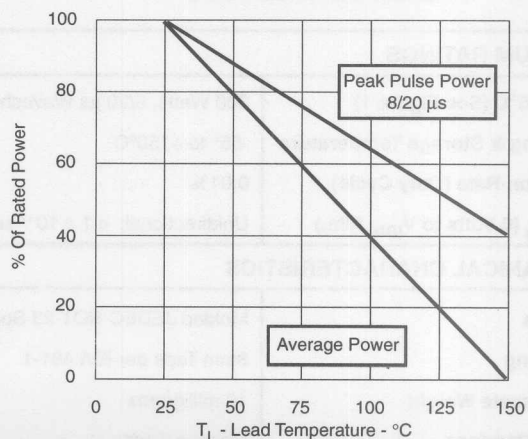
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



COMBINATION HIGH SPEED RAIL CLAMP & TVS ARRAY

APPLICATIONS

- RS-422 & RS-485 Interface Networks
- USB Power & Data Line Protection
- Computer I/O Ports
- Audio/Video Inputs
- Microcontroller Interface Protection
- ISDN Secondary Protection

FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 40 kilovolts
- Low Capacitance - 15 pF
- Protects up to Four (4) I/O Ports
- Available in 3 Voltage Types: 5V, 12V & 15V
- Available in a Standard SO-8 Package
- UL 94V-0 Flammability Classification

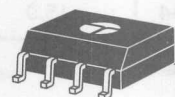
DESCRIPTION

The PSRDAxx-4 series is designed to protect up to four (4) high speed data lines from the effects of electrostatic discharge (ESD), electrically fast transients (EFT) and induced lightning transients.

The PSRDAxx-4 series incorporates an eight (8) steering diode array in a low capacitance configuration with a TVS diode into a single package. This unique design allows the user to protect four (4) high speed data or I/O port lines. The PSRDAxx-4 series is offered in a SO-8 surface mount package with a peak pulse power (P_{PP}) rating of 300 Watts for an 8/20 waveshape.

TVS
Arrays

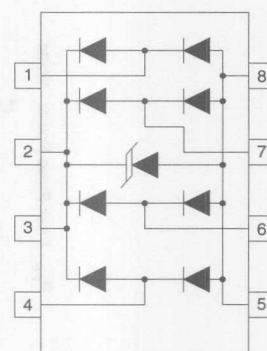
IEC 1000-4 COMPATIBLE



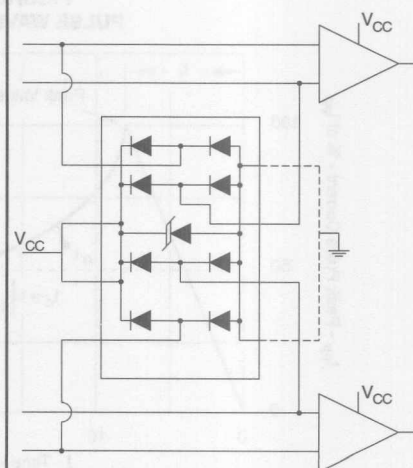
SO-8 PACKAGE

CIRCUIT DIAGRAM

PSRDA05-4
PSRDA12-4
PSRDA15-4



HIGH SPEED DATA LINE APPLICATION



MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
Forward Surge Current (8/20 μ s)	2 Amps
Peak Forward Voltage (8/20 μ s)	3 Volts
Peak Rectifier V_{RRM}	70 Volts
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds

MECHANICAL CHARACTERISTICS

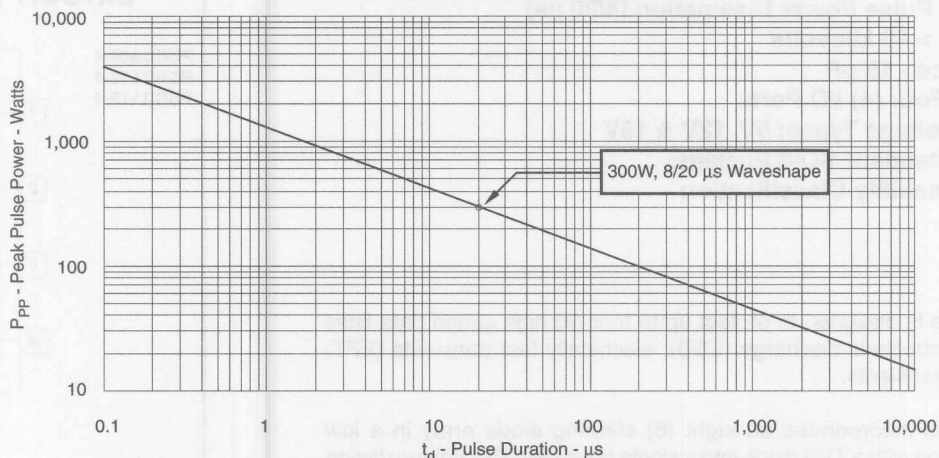
Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

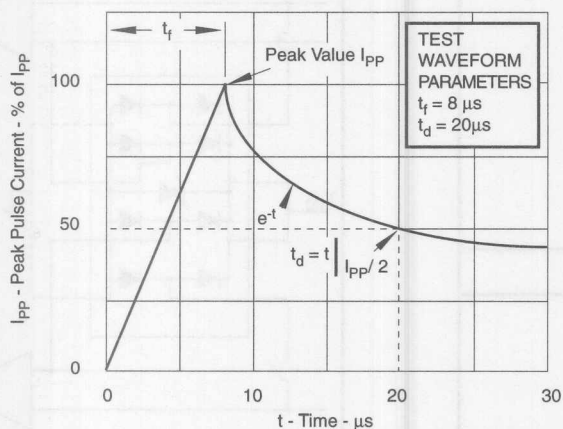
PROTEK PART NUMBER	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MAXIMUM BREAKDOWN VOLTAGE @ 1mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1A$ V_C VOLTS	MAXIMUM FORWARD VOLTAGE @ 100 mA V_F VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ 8/20 μs I_{PP} AMPS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE (See Note 1) C pF
PSRDA05-4	5.0	6.0	9.8	1.1	17	20	15
PSRDA12-4	12.0	13.3	19.0	1.1	12	1	15
PSRDA15-4	15.0	16.7	24.0	1.1	10	1	15

Note 1: Capacitance measured at $V_{WM} = V_{CC}$ connected between pins 2 & 3 and pins 5 & 8. $V_R = V_{WM}$ @ 1 MHz

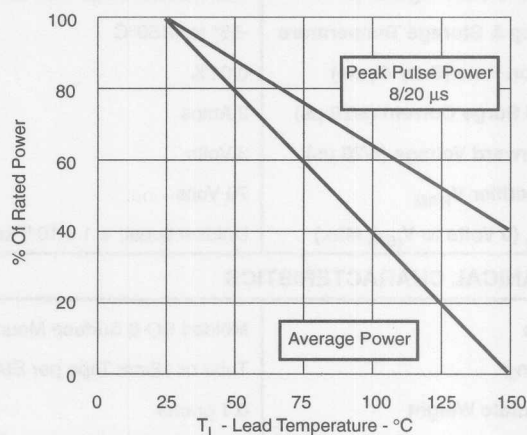
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



APPLICATIONS

- RS-232, RS-422 & RS-423 Data Lines
- Cellular Phones
- Audio/ Video Inputs
- Portable Electronics
- Wireless Network Systems

FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- 300 & 500 Watts Peak Pulse Power Dissipation per Line (8/20 μ s)
- ESD Protection > 40 kilovolts
- Available in 6 Voltage Types Ranging from 3.0V to 24V
- Standard SO-8 Package
- Unidirectional & Bidirectional Configurations
- UL 94V-0 Flammability Classification

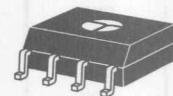
DESCRIPTION

The SMDA/SMDB family is a series of silicon transient voltage suppressor (TVS) arrays designed for use in applications which require multiple line protection where space is at a premium. These devices provide board level ESD and EFT protection to sensitive I/O ports, TTL and MOS bus lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4.

The SMDA series is offered in an SO-8 surface mount package with a peak pulse power rating (P_{PP}) of 300 Watts and the SMDB series has a P_{PP} rating of 500 Watts for an 8/20 μ s waveshape. Both devices can be used to protect combinations of four (4) unidirectional or bidirectional lines.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	300 & 500 Watts, 8/20 μ s Waveshape
Forward Surge Rating	SMDA: 5A, 1/120s @ 25°C (Unidirectional Only) SMDB: 10A, 1/120s @ 25°C (Unidirectional Only)
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

IEC 1000-4 COMPATIBLE

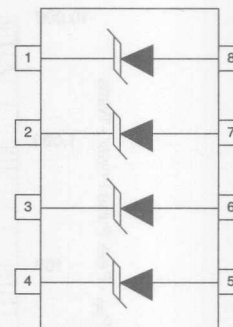


SO-8 PACKAGE

CIRCUIT DIAGRAMS

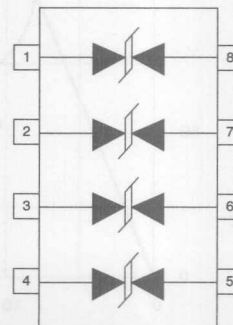
UNIDIRECTIONAL

SMDA03	SMDB05
SMDA05	SMDB08
SMDA08	SMDB12
SMDA12	SMDB15
SMDA15	SMDB24
SMDA24	



BIDIRECTIONAL

SMDA03C	SMDB05C
SMDA05C	SMDB08C
SMDA08C	SMDB12C
SMDA12C	SMDB15C
SMDA15C	SMDB24C
SMDA24C	



ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1 & Note 2)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 10$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF	TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
SMDA03	SDJ	3.0	3.3	4.0	7.5		125	800	
SMDA03C	SDK	3.0	3.3	4.0	9.0		125	800	
SMDA05	SDA	5.0	6.0	9.8	11.0		100	550	6
SMDB05	PDA	5.0	6.0	9.8		12.5	200	880	6
SMDA05C	SDB	5.0	6.0	9.8	11.0		100	400	3
SMDB05C	PDB	5.0	6.0	9.8		12.5	200	500	3
SMDA08	SDJ	8.0	8.5	13.4	16.6		10	500	5
SMDB08	PDJ	8.0	8.5	13.4		16.6	10	800	5
SMDA08C	SDK	8.0	8.5	13.4	16.6		10	300	5
SMDB08C	PDK	8.0	8.5	13.4		16.6	10	400	5
SMDA12	SDC	12.0	13.3	19.0	24.0		1	185	18
SMDB12	PDC	12.0	13.3	19.0		23.5	2	440	18
SMDA12C	SDD	12.0	13.3	19.0	24.0		1	150	16
SMDB12C	PDD	12.0	13.3	19.0		23.5	2	385	16
SMDA15	SDE	15.0	16.7	24.0	30.0		1	140	20
SMDB15	PDE	15.0	16.7	24.0		29.5	2	400	20
SMDA15C	SDF	15.0	16.7	24.0	30.0		1	100	17
SMDB15C	PDF	15.0	16.7	24.0		29.5	2	300	17
SMDA24	SDG	24.0	26.7	43.0	55.0		1	88	30
SMDB24	PDG	24.0	26.7	40.0		46.9	2	275	30
SMDA24C	SDH	24.0	26.7	43.0	55.0		1	63	26
SMDB24C	PDH	24.0	26.7	40.0		46.9	2	200	26

Note 1: Part numbers with a "C" suffix are bidirectional devices.

Note 2: $V_F = 1.5$ Volts @ 100mA, 300 μ s (square wave), unidirectional devices only.

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

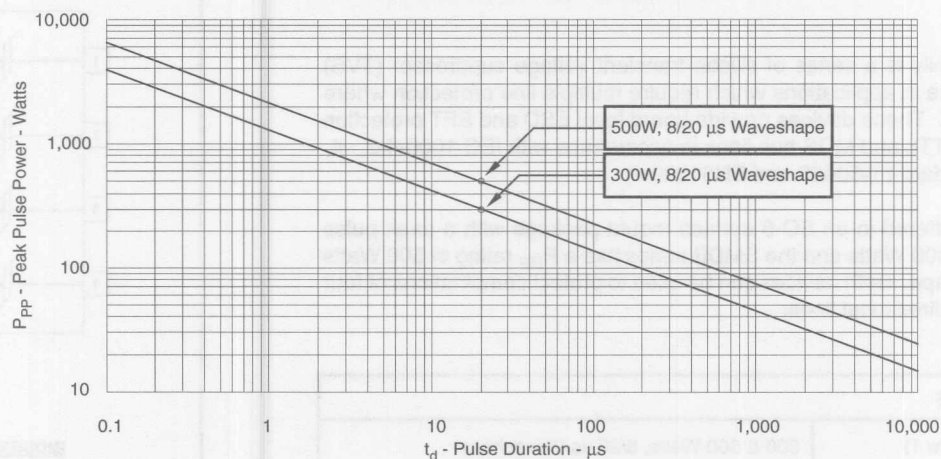


FIGURE 2
PULSE WAVE FORM

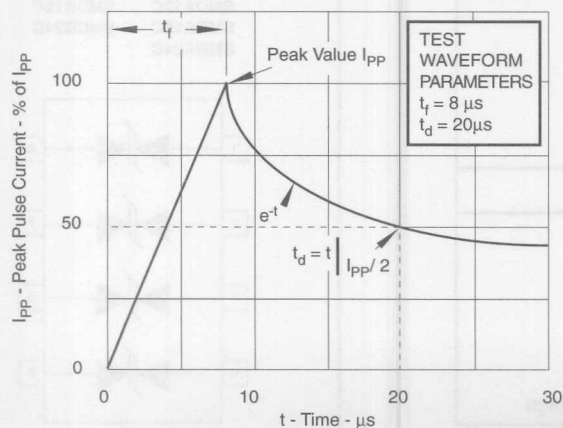
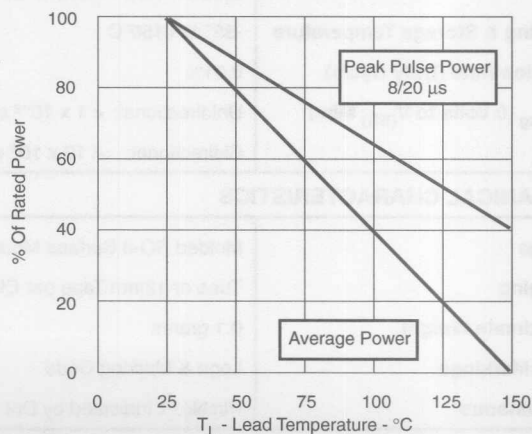


FIGURE 3
POWER DERATING CURVE



BIDIRECTIONAL MONOLITHIC TVS DIODE ARRAY

APPLICATIONS

- RS-232, RS-422 & RS-423 Data Lines
- Microprocessor Based Equipment
- Controller & Monitoring Systems
- Portable Electronics

FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation (8/20 μ s)
- ESD Protection > 40 kilovolts
- Available in 5 Voltage Types Ranging from 5.0V to 24V
- Bidirectional Monolithic Design
- UL 94V-0 Flammability Classification

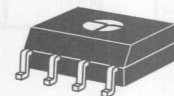
DESCRIPTION

The SMDAxxCM family is a series of bidirectional, surface mount, monolithic, silicon transient voltage suppressor (TVS) arrays designed for use in applications which require multiple line protection where space is at a premium. This series provides board level ESD and EFT protection to I/O ports, TTL and MOS bus lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4.

The SMDAxxCM series has a peak pulse power rating (P_{PP}) of 300 Watts for an 8/20 μ s waveshape. This device can be used to protect up to four (4) line pairs.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to V_{BR} Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

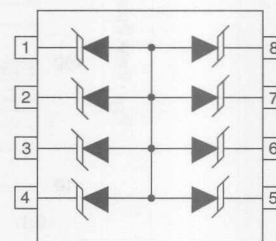
IEC 1000-4 COMPATIBLE



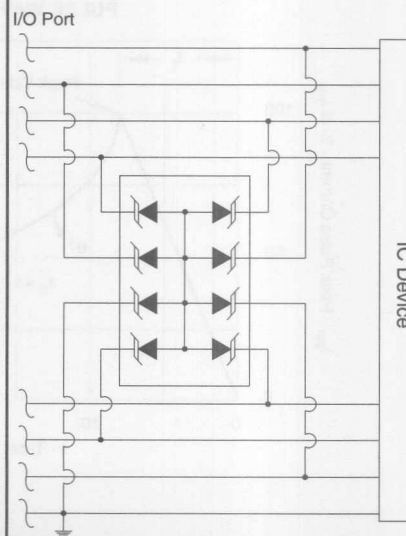
SO-8 PACKAGE

CIRCUIT DIAGRAM

SMDA05CM
SMDA08CM
SMDA12CM
SMDA15CM
SMDA24CM



**BIDIRECTIONAL
DATA LINE APPLICATION**



TVS
Arrays

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF	TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
SMDA05CM	REB	5.0	6.0	9.8	11.0	100	350	6
SMDA08CM	REC	8.0	8.5	13.4	16.6	10	300	8
SMDA12CM	RED	12.0	13.4	19.0	24.0	1	150	18
SMDA15CM	REF	15.0	16.7	24.0	30.0	1	100	20
SMDA24CM	REH	24.0	26.7	43.0	55.0	1	63	30

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

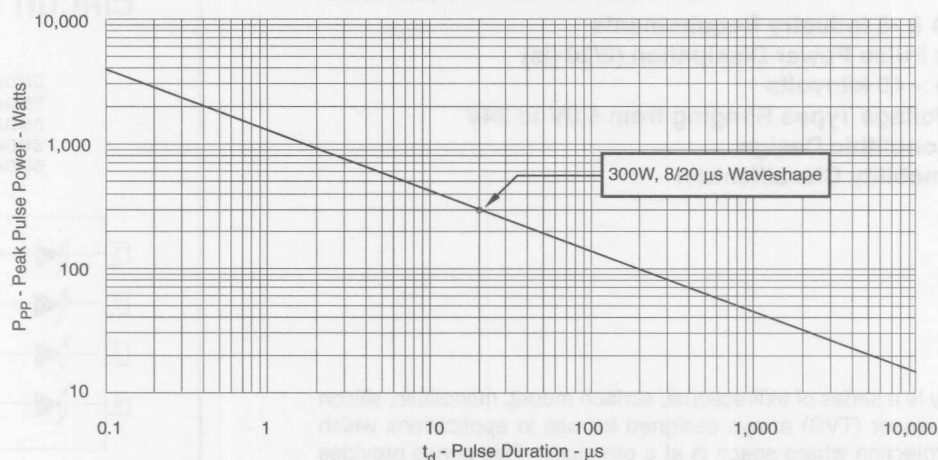


FIGURE 2
PULSE WAVE FORM

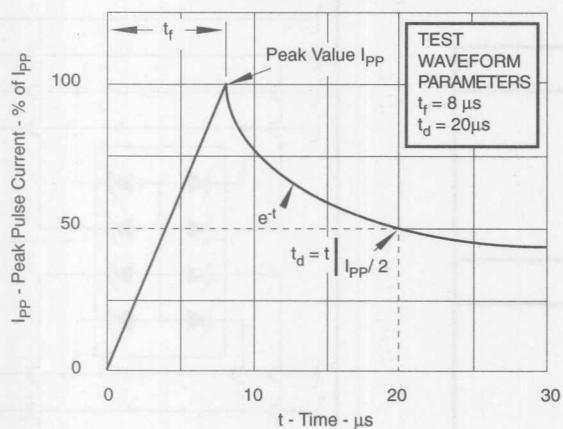
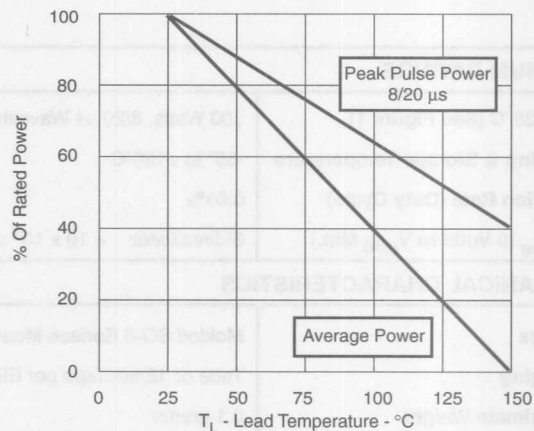


FIGURE 3
POWER DERATING CURVE



HIGH SPEED TVS DIODE ARRAY

APPLICATIONS

- ATM & SCSI Interfaces
- Ethernet & FireWire
- Audio/ Video Inputs
- 100 Base T

FEATURES

- IEC 1000-4-2 & -4 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation per Line (8/20 μ s)
- ESD Protection > 40 kilovolts
- Low Capacitance - 15 pF
- Available in 5 Voltage Types Ranging from 3.0V to 24V
- Standard SO-8 Package
- Unidirectional & Bidirectional Configurations
- UL 94V-0 Flammability Classification

DESCRIPTION

The SMDAxxLC family is a series of low capacitance, silicon transient voltage suppressor (TVS) arrays designed for use in applications which require multiple line protection where space is at a premium. These devices provide board level ESD and EFT protection to sensitive I/O ports, TTL and MOS bus lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4.

The SMDAxxLC series has a peak pulse power rating (P_{PP}) of 300 Watts for an 8/20 μ s waveshape. These devices can be used to protect combinations of four (4) unidirectional or bidirectional lines.

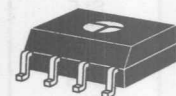
MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	300 Watts per Line, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds

MECHANICAL CHARACTERISTICS

Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

IEC 1000-4 COMPATIBLE

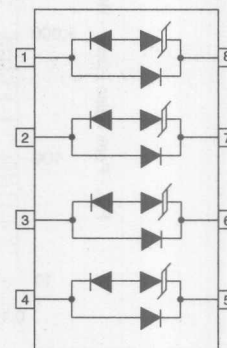


SO-8 PACKAGE

CIRCUIT DIAGRAMS

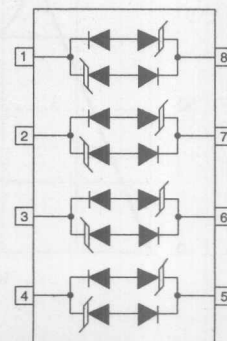
UNIDIRECTIONAL

SMDA03LC
SMDA05LC
SMDA08LC
SMDA12LC
SMDA15LC
SMDA24LC



BIDIRECTIONAL

SMDA03LCC
SMDA05LCC
SMDA08LCC
SMDA12LCC
SMDA15LCC
SMDA24LCC



ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

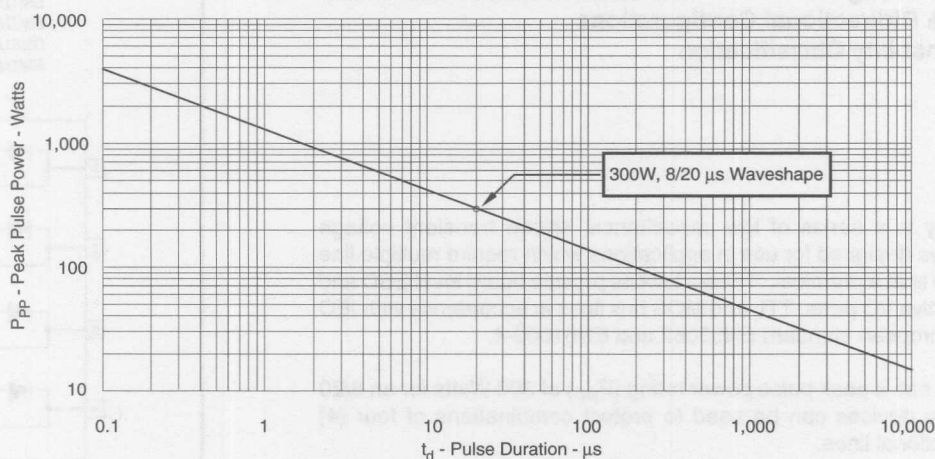
PROTEK PART NUMBER (See Notes 1-3)	DEVICE MARKING CODE	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF	TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
SMDA03LC	SLA	3.3	4.5	7.0	9.0	125	15	-2
SMDA03LCC	SLB	3.3	4.5	7.0	9.0	125	15	-2
SMDA05LC	SLC	5.0	6.0	9.8	12.5	20	15	3
SMDA05LCC	SLD	5.0	6.0	9.8	12.5	20	15	3
SMDA08LC	SLE	8.0	8.5	13.4	16.6	10	15	9
SMDA08LCC	SLF	8.0	8.5	13.4	16.6	10	15	9
SMDA12LC	SLG	12.0	13.3	19.0	23.5	2	15	16
SMDA12LCC	SLH	12.0	13.3	19.0	23.5	2	15	16
SMDA15LC	SLJ	15.0	16.7	25.5	29.5	2	15	17
SMDA15LCC	SLK	15.0	16.7	25.5	29.5	2	15	17
SMDA24LC	SLL	24.0	26.7	43.0	55.0	1	15	25
SMDA24LCC	SLM	24.0	26.7	43.0	55.0	1	15	25

Note 1: For unidirectional devices only - $V_F = 1.5$ Volts @ 50mA peak, 300 μs (Square Wave).

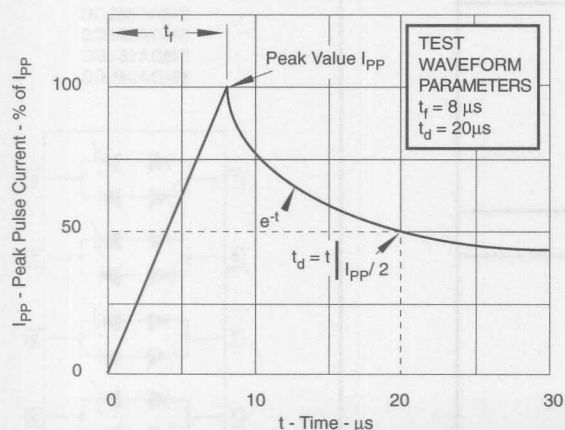
Note 2: Part numbers with an additional "C" suffix are bidirectional devices, i.e., SMDA03LCC.

Note 3: For unidirectional devices only, do not surge from pins 8 to 1, 7 to 2, 6 to 3 and 5 to 4. PIV typically greater than 100 Volts for each rectifier diode.

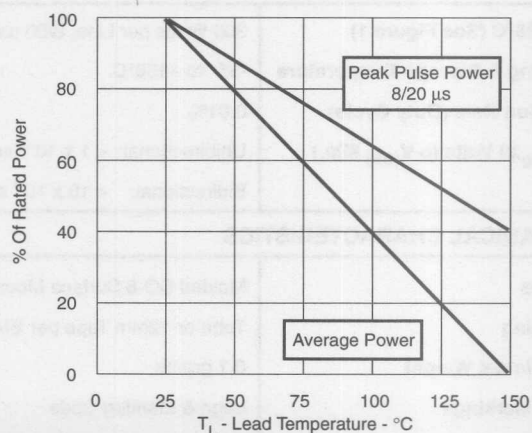
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



HIGH SPEED TVS DIODE ARRAY

APPLICATIONS

- T1/E1
- Cellular Phones
- Digital/ Video Inputs
- Portable Electronics
- Wireless Network Systems

FEATURES

- IEC 1000-4-5 Industry Requirements
- 600 Watts Peak Pulse Power Dissipation per Line Pair (10/1000 μ s)
- 3,600 Watts Peak Pulse Power Dissipation per Line Pair (8/20 μ s)
- High Surge Capability: 80A (10/1000 μ s)
- Fast Response Time
- Protects Two (2) Bidirectional Lines
- Available in 3 Voltage Types Ranging from 5.0V to 12V
- Standard SO-16 Package
- Low Capacitance: < 30 pF per Line Pair
- UL 94V-0 Flammability Classification

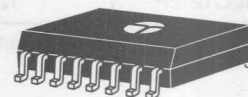
DESCRIPTION

The SMP6LCxx-2P series is a 600 Watt, low capacitance, bidirectional transient voltage suppressor (TVS) array. This device is designed to provide secondary transmission line surge protection for intra-building on both tip-to-ground and ring-to-ground, or tip-to-ring telephone lines. Each line pair is designed to handle the 800 Volt, 100 Amp, 2/10 μ s intra-building lightning surge required by GR1089 and the 10/700 μ s surges required by CCITT K.20, EN61000-4, EN300 386-2 and IEC 1000-4-5.

This series provides current and voltage limiting for metallic TIP/RING surges and take advantage of the isolation provided by the line transformers to prevent damage from longitudinal (common mode) surges to ground. The low capacitance characteristics do not limit the performance of the T1/E1 circuit line cards.

MAXIMUM RATINGS	
P_{pp} @ 25°C (See Figure 1)	600 Watts, 10/1000 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
t_{clamping} (0 Volts to V_(BR) Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-16 Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.15 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

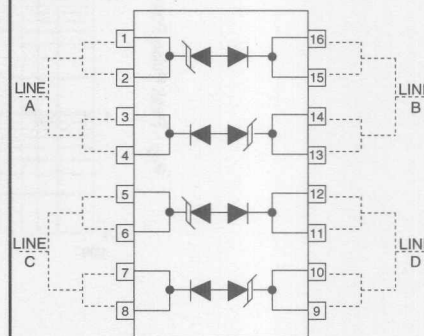
IEC 1000-4 COMPATIBLE



TVS
Arrays

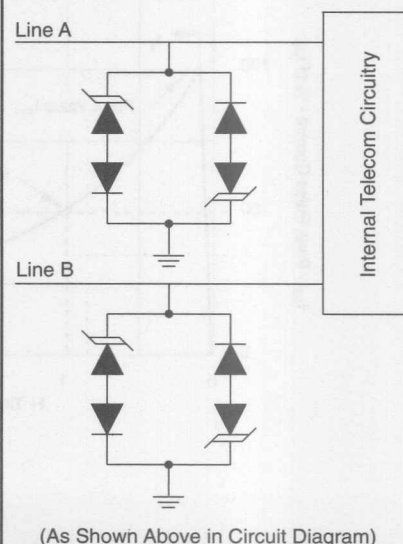
SO-16 PACKAGE

CIRCUIT DIAGRAM



Note 1: Do not surge from pins 15/16 to 1/2, 3/4 to 13/14, 11/12 to 5/6 and 7/8 to 9/10.

TYPICAL SLIC CARD APPLICATION

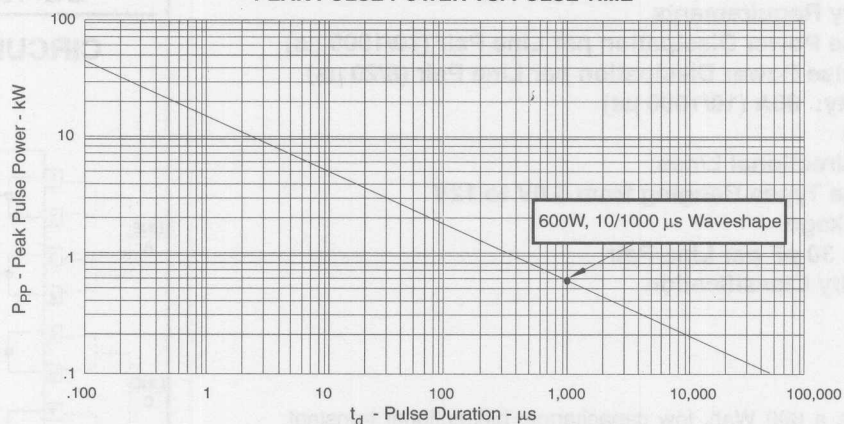


ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

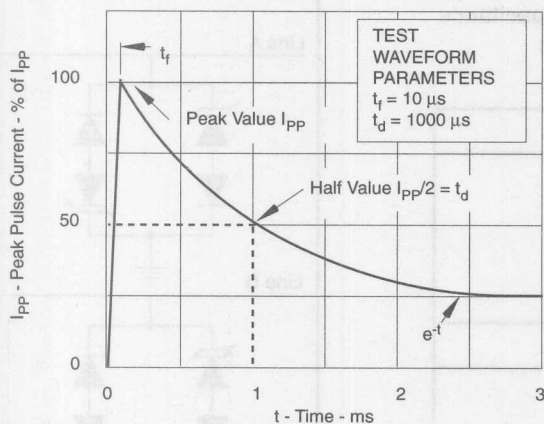
PROTEK PART NUMBER (See Note 1)	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_{PP} = 10A$ V_C VOLTS	TYPICAL CAPACITANCE @ 0V, 1 MHz C pF
SMP6LC05-2P	5.0	6.0	300	9.6	15
SMP6LC6.5-2P	6.5	7.2	300	12.4	15
SMP6LC12-2P	12.0	13.3	2.0	19.9	15

Note 1: Do not surge from pins 15/16 to 1/2, 3/4 to 13/14, 11/12 to 5/6 and 7/8 to 9/10. PIV typically greater than 100 Volts for each rectifier diode.

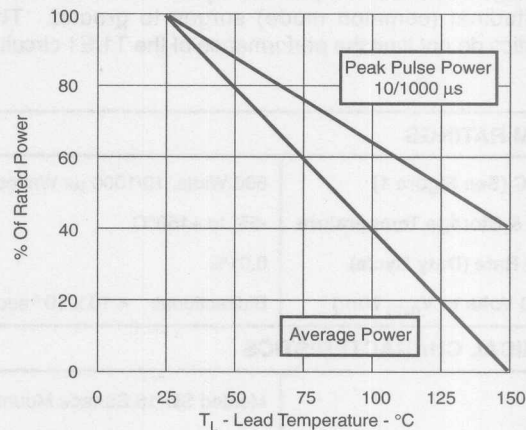
**FIGURE 1
PEAK PULSE POWER VS. PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



HIGH SPEED TVS DIODE ARRAY

APPLICATIONS

- Video-on-Demand
- ISDN Telecom Interface
- USB, ADSL & SCSI Interfaces
- Modems
- Portable Electronics
- LAN Interconnects

FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- 500 Watts Peak Pulse Power Dissipation per Line Pair (8/20 μ s)
- ESD Protection > 40 kilovolts
- Low Capacitance: < 25 pF
- Available in 5 Voltage Types Ranging from 5.0V to 24V
- Standard SO-8 Package
- Two Line Pairs per Package
- Bidirectional Configurations
- UL 94V-0 Flammability Classification

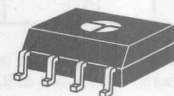
DESCRIPTION

The two (2) line pair SM8LC family is a series of low capacitance, silicon transient voltage suppressor (TVS) arrays designed for use in high-speed data rate applications. These devices provide board level ESD and EFT protection to sensitive I/O ports, TTL and MOS bus lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4.

The SM8LC series has a peak pulse power rating (P_{PP}) of 500 Watts for an 8/20 μ s waveshape. These devices can be used to protect combinations of two (2) bidirectional lines.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	500 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to V_{BR} Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

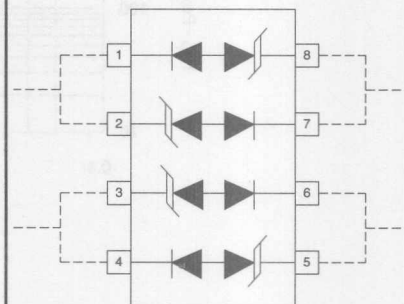
IEC 1000-4 COMPATIBLE



SO-8 PACKAGE

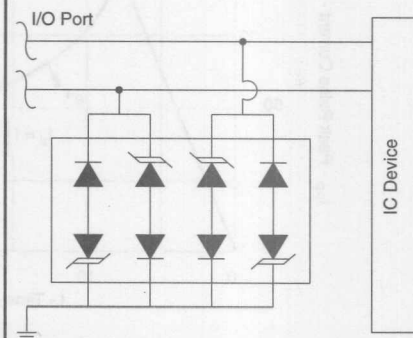
CIRCUIT DIAGRAM

SM8LC05
SM8LC08
SM8LC12
SM8LC15
SM8LC24



1. For Bidirectional applications, connect external pins 1 & 2, 3 & 4, 5 & 6, 7 & 8 as shown in the above circuit diagram.
2. Do not surge from pins 1 to 8, 7 to 2, 6 to 3 and 4 to 5. PIV typically greater than 100 Volts.

I/O PORT PROTECTION APPLICATION



		V_{WM} VOLTS	@ 1 mA $V_{(BR)}$ VOLTS	(See Fig. 2) @ $I_p = 1$ A V_C VOLTS	(See Fig. 2) @ $I_p = 10$ A V_C VOLTS	@ V_{WM} I_D μA	@ 0V, 1 MHz C pF	$\Theta V_{(BR)}$ mV/°C
SM8LC05	PGA	5.0	6.0	9.8	12.5	100	25	3
SM8LC08	PGB	8.0	8.5	13.3	16.6	10	25	6
SM8LC12	PGC	12.0	13.3	19.0	23.5	4	25	16
SM8LC15	PGD	15.0	16.7	25.5	29.5	4	25	17
SM8LC24	PGE	24.0	26.7	40.0	46.9	4	25	26

Note 1: Devices are designed to be used in parallel (See Circuit Diagram). For other applications, contact the factory. Do not surge in the "forward" direction of the TVS.
Note 2: Do not surge from pins 1 to 8, 7 to 2, 6 to 3 and 4 to 5. PIV typically greater than 100 Volts for each rectifier diode.

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

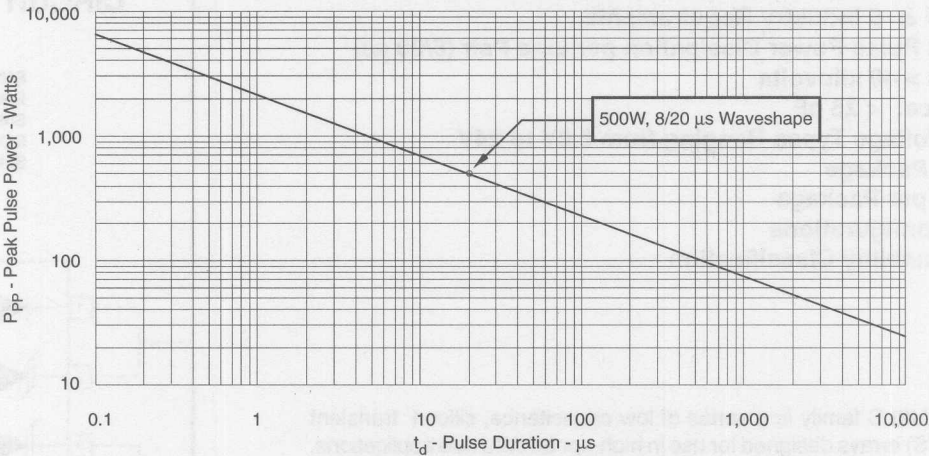


FIGURE 2
PULSE WAVE FORM

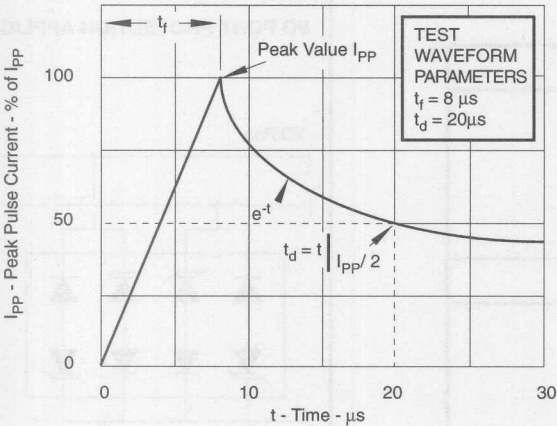
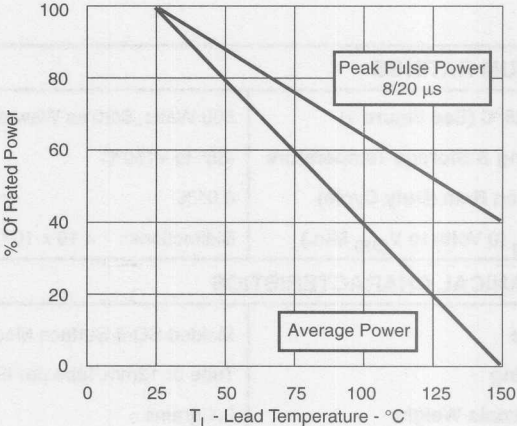


FIGURE 3
POWER DERATING CURVE



BIDIRECTIONAL MONOLITHIC TVS DIODE ARRAY

APPLICATIONS

- Multiple I/O Port Protection
- Board Level Interface Connection
- RS-232, RS-422, RS-423 & RS-485

FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- 500 Watts Peak Pulse Power Dissipation (8/20 μ s)
- 2,500 Watts Peak Pulse Power Dissipation per Package (8/20 μ s)
- ESD Protection > 40 kilovolts
- Bidirectional Monolithic Design
- Available in 5 Voltage Types Ranging from 5.0V to 24V
- UL 94V-0 Flammability Classification

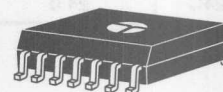
DESCRIPTION

The SM14MxxC family is a series of bidirectional, monolithic, silicon transient voltage suppressor (TVS) arrays designed for use in applications which require multiple line protection where space is at a premium. These devices provide board level ESD and EFT protection to sensitive I/O ports, TTL and MOS bus lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4 requirements.

The SM14MxxC series has a peak pulse power rating (P_{PP}) of 500 Watts for an 8/20 μ s waveshape and 2,500 Watts P_{PP} rating per package for an 8/20 μ s waveshape. These devices can be used to protect up to eight (8) bidirectional lines.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	500 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-14 Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Common Ground Pins	Pin Nos. 1, 7, 8 & 14
Approximate Weight	0.15 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

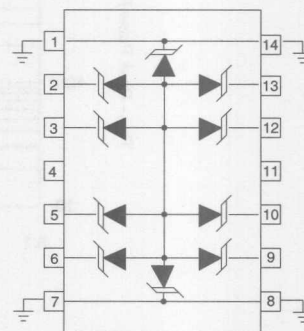
IEC 1000-4 COMPATIBLE



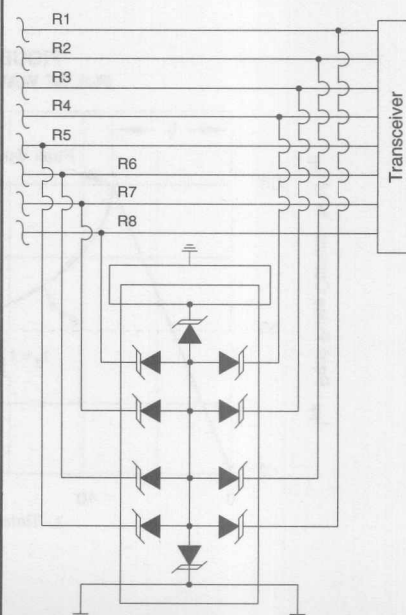
SO-14 PACKAGE

CIRCUIT DIAGRAM

SM14M05C
SM14M08C
SM14M12C
SM14M15C
SM14M24C



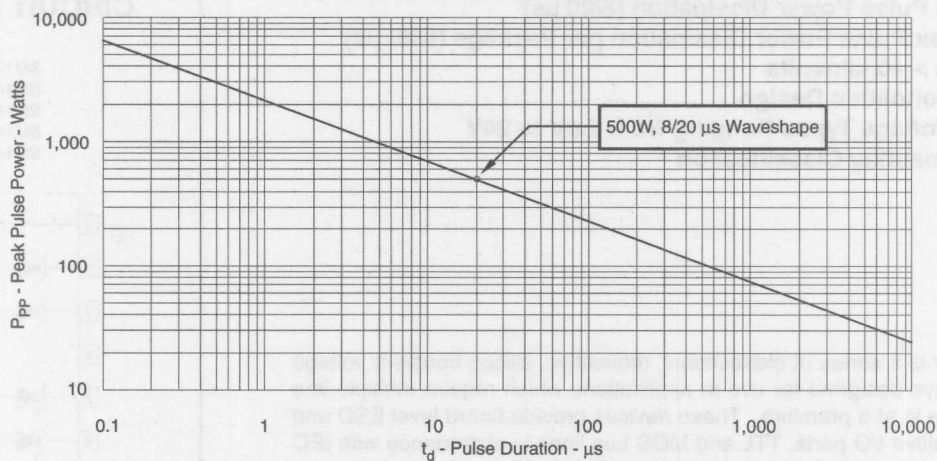
TYPICAL APPLICATION



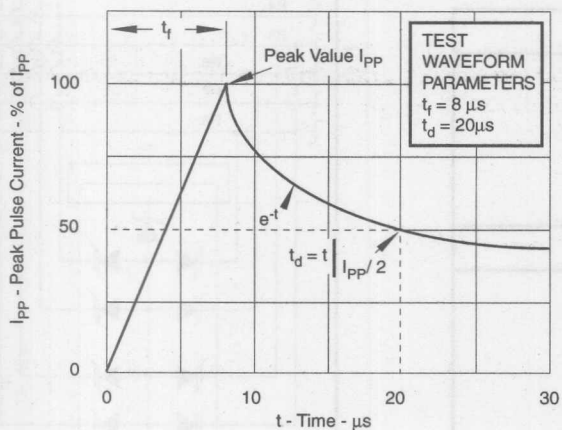
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 10$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF	TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
SM14M05C	5.0	6.0	9.8	12.5	100	500	3
SM14M08C	8.0	8.5	13.4	15.0	10	440	9
SM12M12C	12.0	13.3	19.0	24.0	2	385	16
SM14M15C	15.0	16.7	24.0	30.0	2	300	17
SM14M24C	24.0	26.7	43.0	51.0	2	200	20

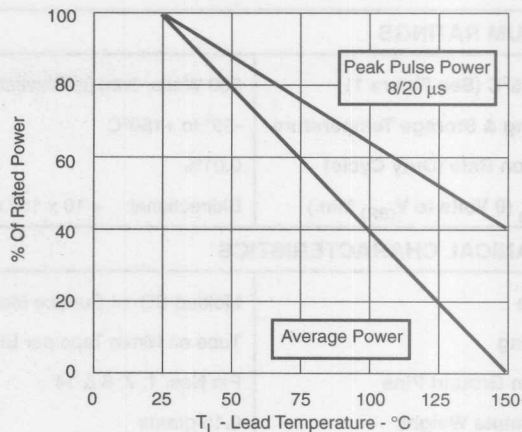
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



HIGH SPEED UNIDIRECTIONAL TVS DIODE ARRAY

APPLICATIONS

- Wireless Communication Circuits
- RS-422, RS-423 & RS-485
- SCSI Bus Lines
- Low Voltage ASICs
- Microprocessor Bus Interface
- 10/100 Base T Ethernet Interface

FEATURES

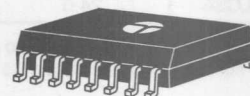
- IEC 1000-4-2, -4 & -5 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation per Line (8/20 μ s)
- ESD Protection > 40 kilovolts
- Available in 5 Voltage Types Ranging from 5.0V to 24V
- Low Capacitance - 15 pF
- Standard SO-16 Package
- Multiple-line Diode Array
- UL 94V-0 Flammability Classification

DESCRIPTION

The SM16LC family is a series of unidirectional, low capacitance, silicon transient voltage suppressor (TVS) arrays designed for use in applications where voltage transients can permanently damage voltage sensitive components. These devices have been designed to protect multiple data or signal lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4 requirements. Each pair of line/ ground pins are electrically independent for multiple I/O port protection.

The SM16LC series has a peak pulse power rating (P_{PP}) of 300 Watts an 8/20 μ s waveshape. This device can be used to protect combinations of eight (8) unidirectional lines.

IEC 1000-4 COMPATIBLE

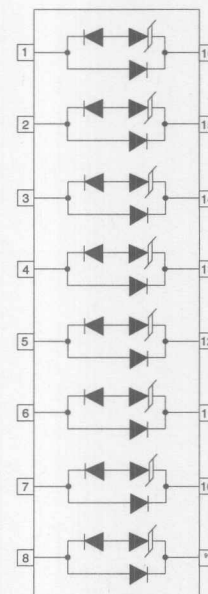


TVS
Arrays

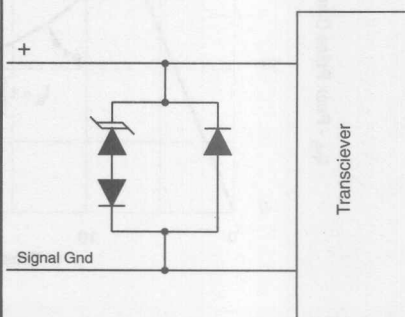
SO-16 PACKAGE

CIRCUIT DIAGRAM

SM16LC05
SM16LC08
SM16LC12
SM16LC15
SM16LC24



High Speed Unbalanced Data Line Application



MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to V_{BR} Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds

MECHANICAL CHARACTERISTICS

Package	Molded SO-16 Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.15 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

(See Note 1 & 2)	V_{WM} VOLTS	@ 1 mA $V_{(BR)}$ VOLTS	(See Fig. 2) @ $I_P = 1$ A V_C VOLTS	(See Fig. 2) @ $I_P = 5$ A V_C VOLTS	@ V_{WM} I_D μA	@ 0V, 1 MHz C pF	$\Theta V_{(BR)}$ mV/°C
SM16LC05	5.0	6.0	9.8	12.5	20	15	3
SM16LC08	8.0	8.5	13.4	16.6	10	15	9
SM16LC12	12.0	13.3	19.0	23.5	2	15	16
SM16LC15	15.0	16.7	25.5	29.5	2	15	17
SM16LC24	24.0	26.7	40.0	46.9	2	15	26

Note 1: $V_F = 1.5$ Volts @ 50mA peak, 300 μs (Square Wave).

Note 2: Do not surge from pins 16 to 1, 15 to 2, 14 to 3, 13 to 4, 12 to 5, 11 to 6, 10 to 7 and 9 to 8. PIV typically greater than 100 Volts for each rectifier diode.

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

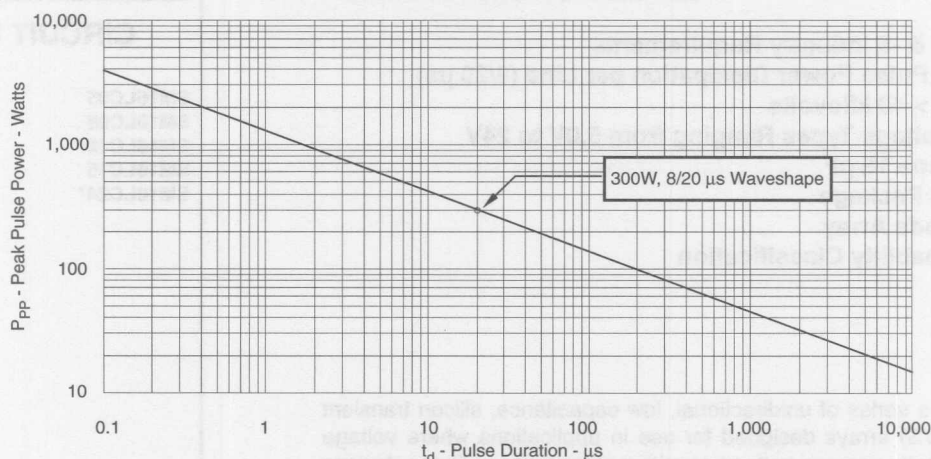


FIGURE 2
PULSE WAVE FORM

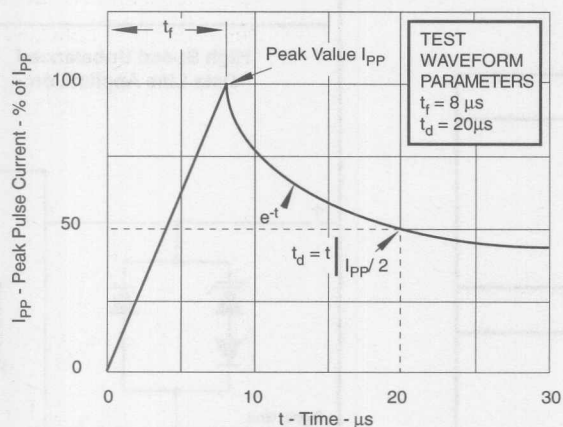
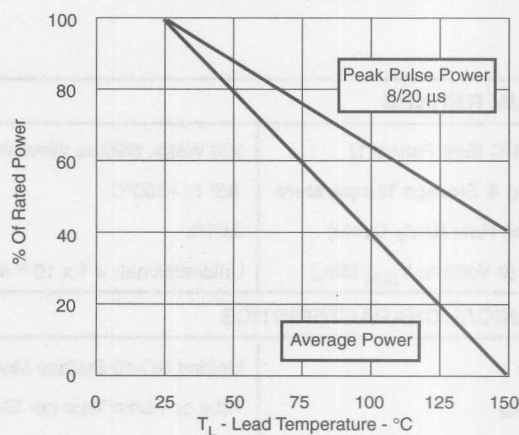


FIGURE 3
POWER DERATING CURVE



HIGH SPEED BIDIRECTIONAL TVS DIODE ARRAY

APPLICATIONS

- RS-422, RS-423 & RS-485 Data Lines
- SCSI Bus Lines
- T1/E1
- FireWire, ATM, Ethernet Interfaces
- High Band Width Applications
- Video/ Data Signals
- Wireless Communication Circuits

FEATURES

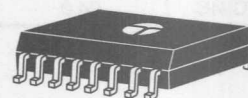
- IEC 1000-4-2, -4 & -5 Industry Requirements
- 300 Watts Peak Pulse Power Dissipation per Line (8/20 μ s)
- ESD Protection > 40 kilovolts
- Available in 5 Voltage Types Ranging from 5.0V to 24V
- Low Capacitance - 15 pF
- Standard SO-16 Package
- Multiple-line Diode Array
- UL 94V-0 Flammability Classification

DESCRIPTION

The SM16LCxxC family is a series of bidirectional, low capacitance, silicon transient voltage suppressor (TVS) arrays designed for use in applications where voltage transients can permanently damage voltage sensitive components. These devices have been designed to protect multiple data or signal lines in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4. Each pair of line/ground pins are electrically independent for multiple I/O port protection.

The SM16LC series has a peak pulse power rating (P_{PP}) of 300 Watts an 8/20 μ s waveshape. This device can be used to protect combinations of eight (8) bidirectional lines.

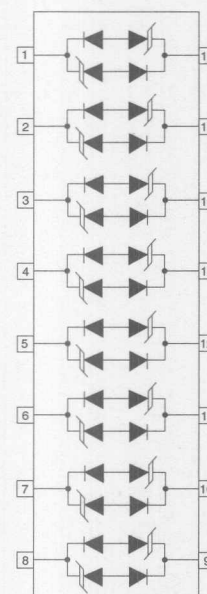
IEC 1000-4 COMPATIBLE



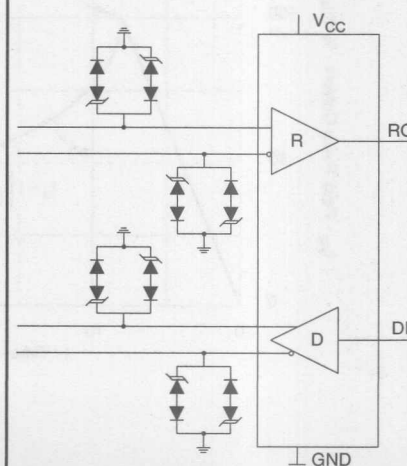
SO-16 PACKAGE

CIRCUIT DIAGRAM

SM16LC05C
SM16LC08C
SM16LC12C
SM16LC15C
SM16LC24C



High Speed Balanced Data Line Appl.



MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	300 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Bidirectional: 10 x 10 ⁻⁹ seconds

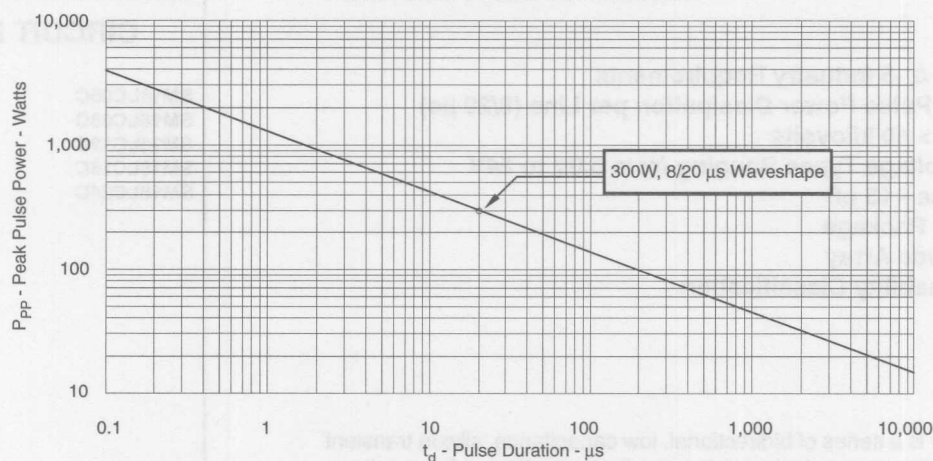
MECHANICAL CHARACTERISTICS

Package	Molded SO-16 Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.15 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

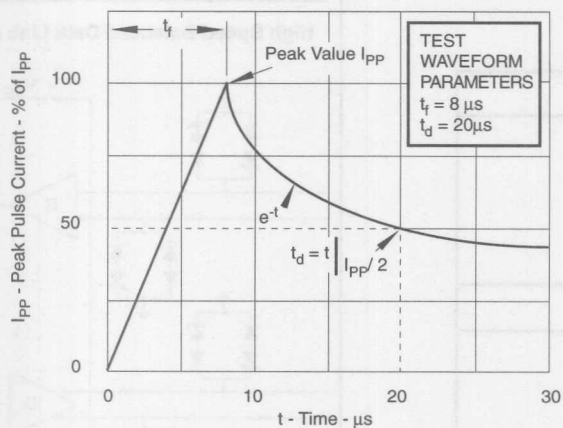
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF	TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
SM16LC05C	5.0	6.0	9.8	12.5	20	15	3
SM16LC08C	8.0	8.5	13.4	16.6	10	15	9
SM16LC12C	12.0	13.3	19.0	23.5	2	15	16
SM16LC15C	15.0	16.7	25.5	29.5	2	15	17
SM16LC24C	24.0	26.7	40.0	46.9	2	15	26

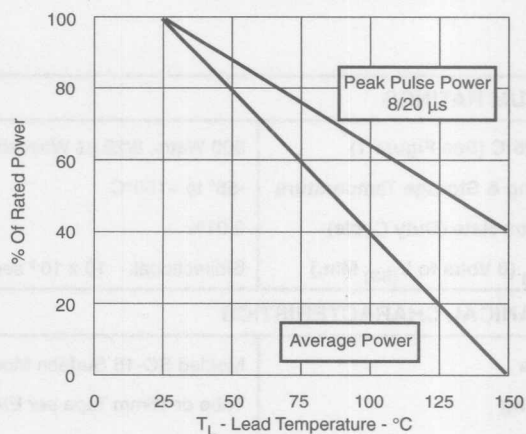
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



HIGH POWER TELCOM TVS DIODE ARRAY

APPLICATIONS

- RS-422, RS-423 & RS-485 Data Lines
- SCSI Bus Lines
- Board Level Interface Protection
- Industrial & Instrumentation
- Portable Electronics
- Power Supplies

FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- 600 Watts Peak Pulse Power Dissipation per Line (10/1000 μ s)
- ESD Protection > 40 kilovolts
- Low Clamping Voltage
- Available in 11 Voltage Types Ranging from 5.0V to 58V
- Unidirectional & Bidirectional Configurations
- Four (4) TVS Devices per Package
- UL 94V-0 Flammability Classification

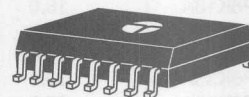
DESCRIPTION

The SM16P6K series are four line, surface mount, silicon transient voltage suppressor (TVS) arrays designed for multiple power and data line applications. This series provides protection against ESD, EFT, secondary lightning, and switching transients in accordance with IEC 1000-4-2, -4, -5 and European standard EN50082 and EN61000-4. This device was designed to replace four P6KE devices in a single package with 600 Watts per line. In addition, there is complete isolation between devices to reduce cross talk or noise interference.

The SM16P6K series is available in a standard SO-16 surface mount package with a peak pulse power rating (P_{PP}) of 600 Watts per line for an 10/1000 μ s waveshape.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	600 Watts per Line, 10/1000 μ s Waveshape
Forward Surge Rating	100A, 1/120 seconds at 25°C (Unidirectional Only)
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-16 Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.15 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

IEC 1000-4 COMPATIBLE

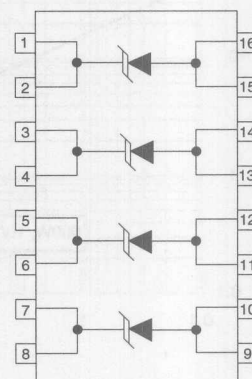


SO-16 PACKAGE

CIRCUIT DIAGRAMS

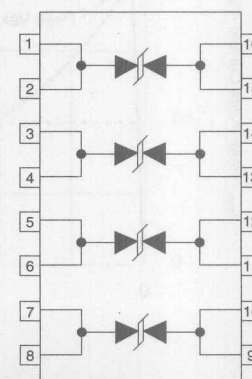
UNIDIRECTIONAL

SM16P6K05A	SM16P6K28A
SM16P6K08A	SM16P6K33A
SM16P6K12A	SM16P6K36A
SM16P6K15A	SM16P6K48A
SM16P6K18A	SM16P6K58A
SM16P6K24A	



BIDIRECTIONAL

SM16P6K05CA	SM16P6K28CA
SM16P6K08CA	SM16P6K33CA
SM16P6K12CA	SM16P6K36CA
SM16P6K15CA	SM16P6K48CA
SM16P6K18CA	SM16P6K58CA
SM16P6K24CA	



NUMBER (See Note 1)	VOLTAGE	VOLTAGE	VOLTAGE (See Fig. 3)	CURRENT	CURRENT (See Fig. 3)	OF $V_{(BR)}$
	V_{WM} VOLTS	@ 1 mA $V_{(BR)}$ VOLTS	@ $I_P = 1$ A V_C VOLTS	@ V_{WM} I_D μA	@ I_{PP} I_{PPM} AMPS	$\Theta V_{(BR)}$ mV/°C
SM16P6K05A	5.0	6.4	9.2	800	65	5
SM16P6K08A	8.0	8.9	13.6	50	44	7
SM16P6K12A	12.0	13.3	19.9	5	30	12
SM16P6K15A	15.0	16.7	24.4	5	24	16
SM16P6K18A	18.0	20.0	29.2	5	21	20
SM16P6K24A	24.0	26.7	38.9	5	15	28
SM16P6K28A	28.0	31.1	45.4	5	13	31
SM16P6K33A	33.0	36.7	53.3	5	11	39
SM16P6K36A	36.0	40.0	58.1	5	10	41
SM16P6K48A	48.0	53.3	77.4	5	7.7	56
SM16P6K58A	58.0	64.4	93.6	5	6.4	70

Note 1: Part numbers shown are for unidirectional devices. Add a "CA" suffix to specify bidirectional devices, such as SM16P6K05CA.

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

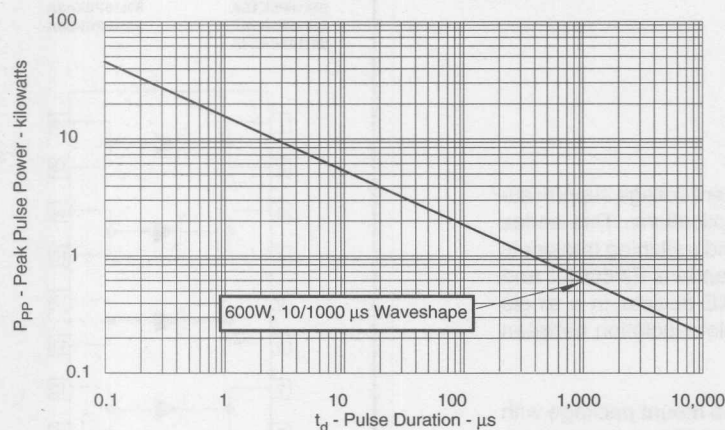


FIGURE 2
TYPICAL CAPACITANCE vs $V_{(BR)}$

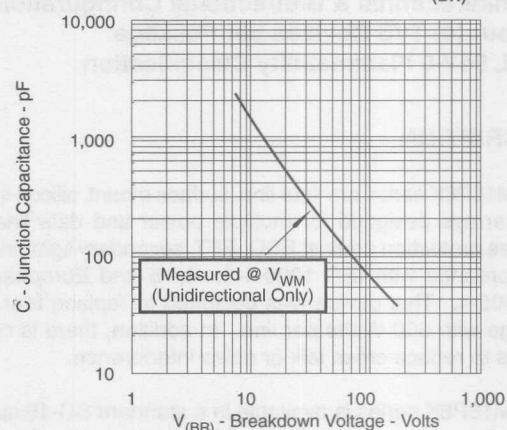


FIGURE 3
PULSE WAVE FORM

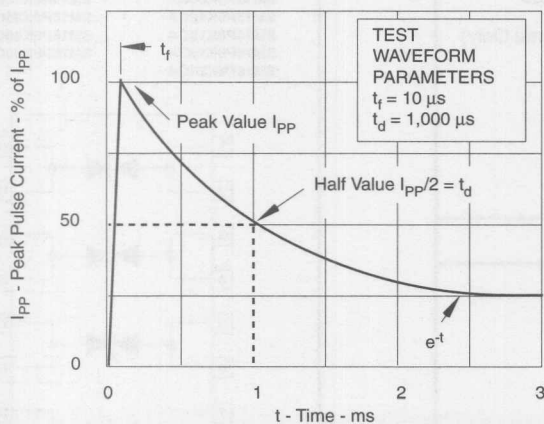
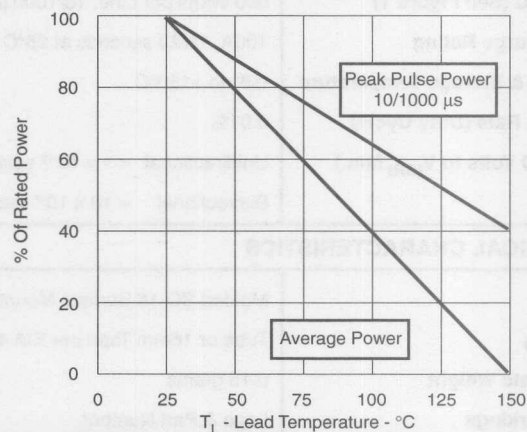


FIGURE 4
POWER DERATING CURVE



UNIDIRECTIONAL MONOLITHIC TVS DIODE ARRAY

APPLICATIONS

- Multiple I/O Port Protection
- Board Level Interface Connections
- RS-232, RS-422 & RS-423 Data Lines
- Portable Electronics

FEATURES

- IEC 1000-4-2 & -4 Industry Requirements
- 175 Watts Peak Pulse Power Dissipation per Line (8/20 μ s)
- ESD Protection > 40 kilovolts
- Protects 5.0 Volt IC Components
- Standard SO-20L Package
- Low Clamping Voltage
- Unidirectional Monolithic Design
- UL 94V-0 Flammability Classification

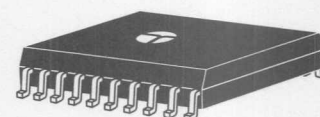
DESCRIPTION

The SM20M05-18 is a unidirectional eighteen (18) line monolithic, silicon transient voltage suppressor (TVS) array designed for power or data line applications. This device is designed to provide protection against ESD, tertiary lightning, and switching transients at the printed circuit board level. The SM20M05-18 protects against the electromagnetic compatibility (EMC) transient immunity standards IEC 1000-4-2, -4 and European standard EN50082 and EN61000-4.

The SM20M05-18 has a peak pulse power rating (P_{PP}) of 175 Watts an 8/20 μ s waveshape. This device is offered in a standard SO-20L package in a unidirectional configuration.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	175 Watts, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to V_{BR}) Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds
MECHANICAL CHARACTERISTICS	
Package	Molded SO-20L(Wide Body) Surface Mount Package
Packaging	Tube or 24mm Tape per EIA 481
Common Ground Pins	6 & 16
Approximate Weight	0.6 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

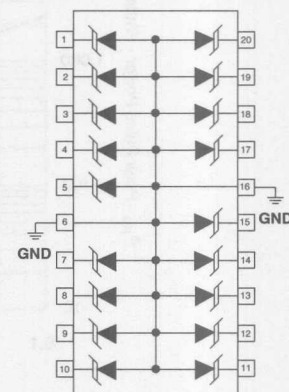
IEC 1000-4 COMPATIBLE



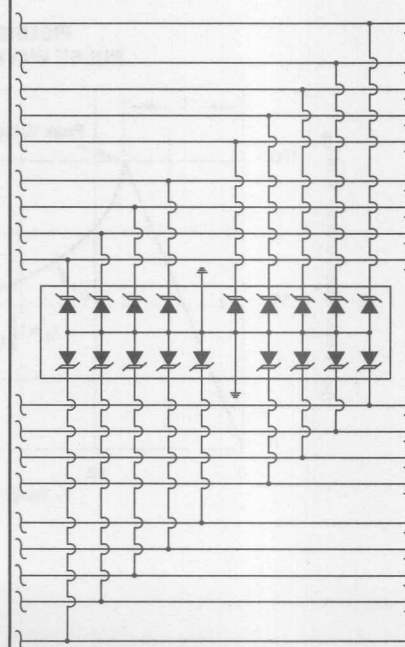
TVS
Arrays

SO-20L PACKAGE

CIRCUIT DIAGRAM



DC DATALINE APPLICATION



ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1$ A V_C VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 5$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM FORWARD VOLTAGE @ 200 MA V_F VOLTS	TYPICAL CAPACITANCE @ 0V, 1 MHz C pF
SM20M05-18	5.0	6.0	9.8	11.0	20	1.25	120

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

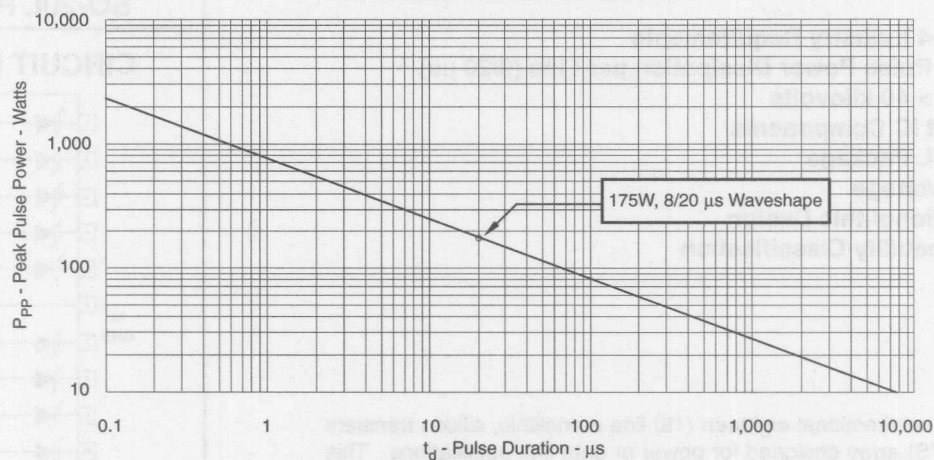


FIGURE 2
PULSE WAVE FORM

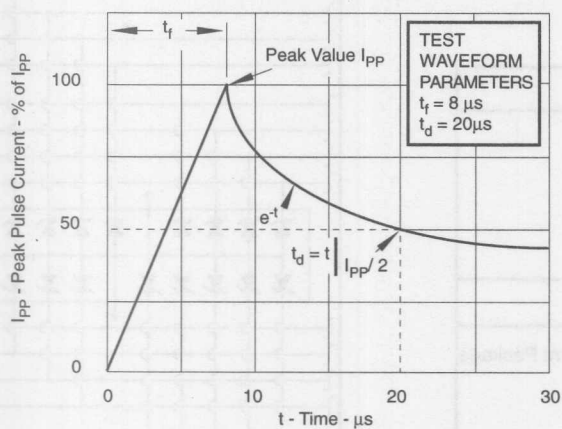
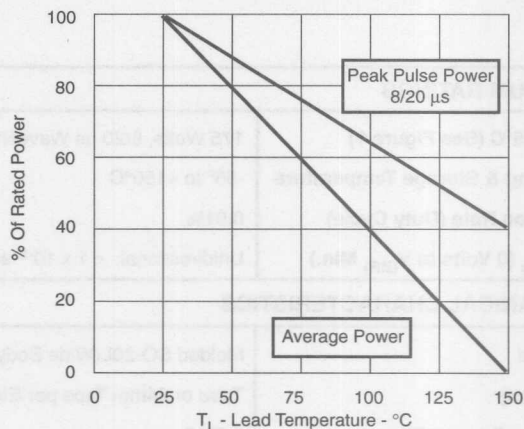


FIGURE 3
POWER DERATING CURVE



BIDIRECTIONAL MONOLITHIC TVS DIODE ARRAY

APPLICATIONS

- RS-232, RS-422 & RS-423 Data Lines
- Industrial & Instrumentation Equipment
- Board Level Interface Protection
- I/O Port Protection

FEATURES

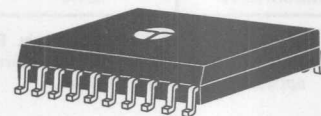
- IEC 1000-4-2, -4 & -5 Industry Requirements
- 1,500 Watts Peak Pulse Power Dissipation per Line (8/20 μ s)
- Low Inductance, Crosstalk & Low Overshoot Voltage
- ESD Protection > 40 kilovolts
- Available in 4 Voltage Types Ranging from 5.0V to 24V
- Up to 9 Bidirectional Data Lines of Protection
- Externally Low Clamping Voltage
- Bidirectional Monolithic Design
- UL 94V-0 Flammability Classification

DESCRIPTION

The SM20MTxxC family is a series of bidirectional, monolithic, silicon transient voltage suppressor (TVS) arrays designed to provide protection against ESD and EFT. The SM20MTxxC surface mount series is designed to protect up to nine (9) bidirectional I/O ports against IEC 1000-4-2, -4, -5 requirements and specifically for RS-232 and RS-423. This device provides a low clamping voltage at a high surge current of 40 Amps based on an 8/20 waveshape and 1,500 Watts per line peak pulse power (P_{PP}) rating for an 8/20 μ s waveshape. When subjected to fast rise time transient events such as ESD and EFT, the SM20MTxxC series yields a low overshoot voltage with a minimum lead inductance.

The SM20MTxxC series has a low inductance package consisting of a 4-point structure with isolated input to output pins that eliminates overshoot voltage due to external lead attachments and perturbations caused by parasitic inductances. This unique internal design provides protection against very high (di/dt) rates such as ESD. Considered an in-line protection device, the monolithic chip design and internal construction ensures reliable protection against the very fast transient overvoltage ESD events, such as Human Body Model (HBM), Machine Model (MM), and Charge Device Model (CDM).

IEC 1000-4 COMPATIBLE

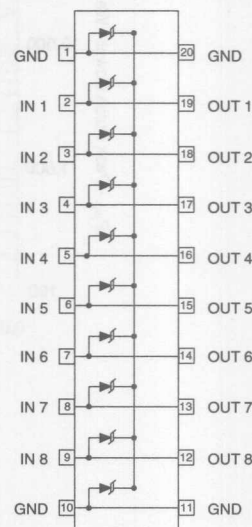


TVS
Arrays

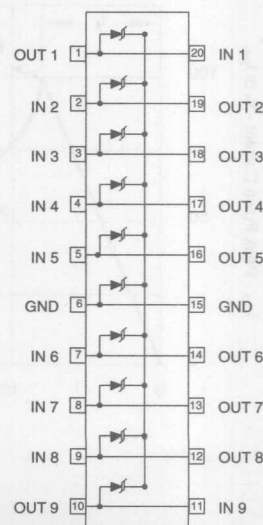
SO-20L PACKAGE

CIRCUIT DIAGRAMS

EQUAL TO 8 BIDIRECTIONAL TVS DEVICES



EQUAL TO 9 BIDIRECTIONAL TVS DEVICES



MAXIMUM RATINGS

P_{PP} @ 25°C (See Figure 1)	1,500 Watts per Line, 8/20 μ s Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
$t_{Clamping}$ (0 Volts to $V_{(BR)}$ Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds

MECHANICAL CHARACTERISTICS

Package	Molded SO-20L Wide Body Surface Mount Package
Packaging	Tube or 24mm Tape per EIA 481
Approximate Weight	0.5 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

NUMBER (See Note 1)	VOLTAGE V_{WM} VOLTS	VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	VOLTAGE (See Fig. 2) @ $I_P = 10$ A V_C VOLTS	VOLTAGE (See Fig. 2) @ $I_P = 25$ A V_C VOLTS	COMMENT @ V_{WM} I_D μA	@ 1 MHz, 0V C pF
SM20MT05C	5.0	6.5	9.5	11	50	700
SM20MT08C	8.0	10	13	17	10	360
SM20MT15C	15.0	18	23	26	4	250
SM20MT24C	24.0	25	31	36	4	140

Note 1: These devices are bidirectional only. Electrical characteristics apply in both directions. The monolithic TVS array is based on 10 unidirectional P/N junctions with a common cathode and can be configured to offer 8 to 9 bidirectional data lines of protection. The inputs and outputs are symmetrical and can be reversed for specific application layout requirements.

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

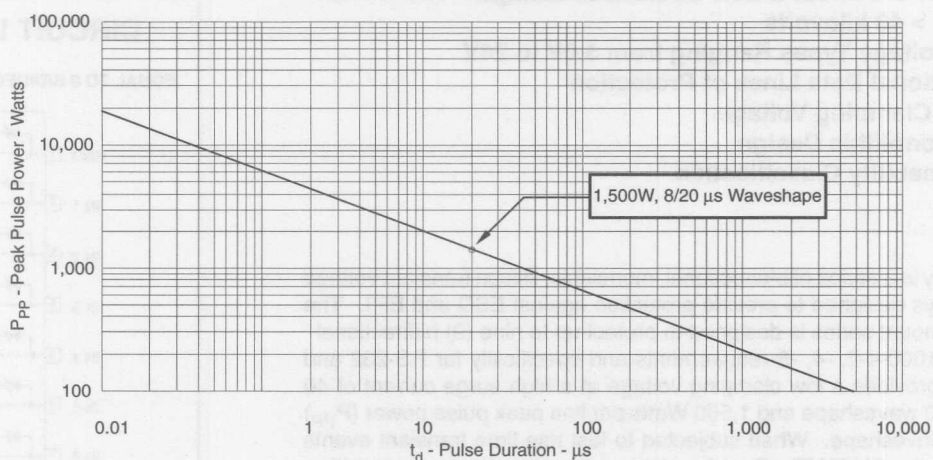


FIGURE 2
PULSE WAVE FORM

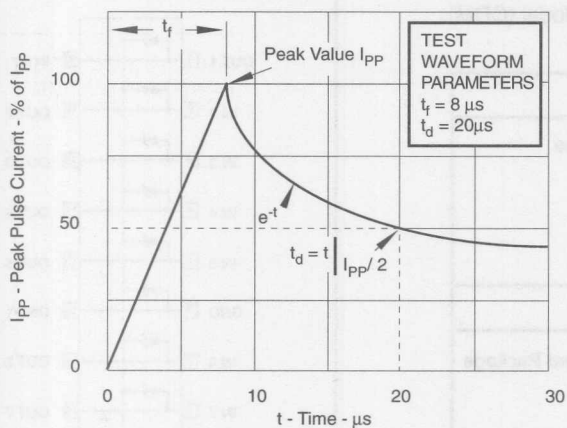
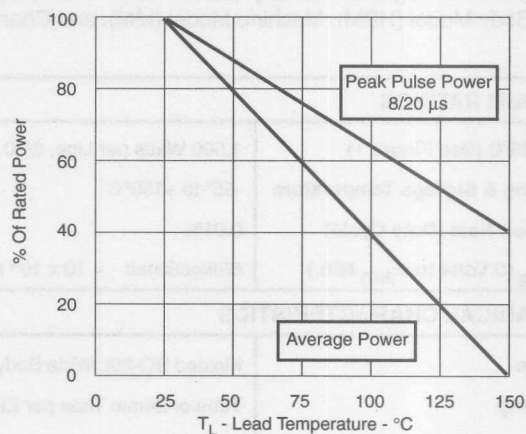


FIGURE 3
POWER DERATING CURVE



LOW CAPACITANCE ISOLATED VSIP TVS ARRAY

APPLICATIONS

- RS-232 & RS-423 Data Lines
- T1/E1 & T3/E3
- ATM Circuit Interface
- ADSL/HDSL & ISDN Interface
- V.34/V.90
- Cable Modem Intra-Structure Protection

FEATURES

- Meets IEC 1000-4-2, -4 & -5 Industry Requirements
- 600 Watts Peak Pulse Power Dissipation (10/1000µs)
- 0.100 Inch Lead Spacing
- Low Capacitance - 25 pF, < 50 pF per Line Pair
- High Surge Capability
- Available in 3 Voltage Types Ranging from 5.0V to 12V
- ESD Protection > 40 kilovolts
- UL 94V-0 Flammability Classification

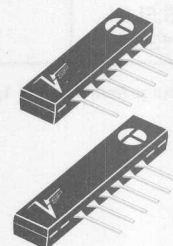
DESCRIPTION

The VSB06PxxLCI family is a series of 600 Watt, low capacitance, bidirectional transient voltage suppressor (TVS) arrays. This series is designed to provide secondary transmission line surge protections for intra-building on both tip-to-ground and ring-to-ground telephone lines. Each line pair is designed to handle to 800V - 100A, 2/10µs intra-building lightning surge required by TR-NWT-001089 (Reference Crystal Semiconductor Group Application Note CS61584 on their T1/E1 product). This device is also capable of meeting the 10/700µs surge required by CCITT K.20, EN61000-4, EN300 386-2 and IEC 1000-2-5.

The VSB06PxxLCI provides current and voltage limiting for metallic TIP/RING surges and takes advantage of the isolation provided by the line transformers to prevent damage from longitudinal (common mode) surges to ground. The low capacitance characteristics do not limit the performance of the T1 and E1 circuit line cards. The single in-line configuration, known as the VSIP®, is designed to be located at the circuit or card edge interface. It is designed on 0.1 inch centers to be consistent with edge card lead spacings.

MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	600 Watts, 10/1000 µs Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
t_{Clamping} (0 Volts to V_(BR) Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded Plastic VSIP Package
Approximate Weight	1.5 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot over Pin 1

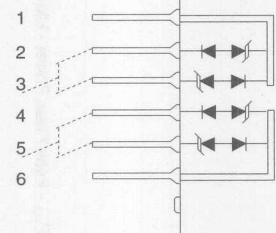
IEC 1000-4 COMPATIBLE



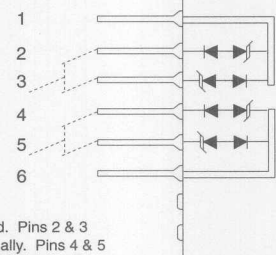
VSIP® PACKAGE

CIRCUIT DIAGRAM

Perferred 8 Pin VSIP Package

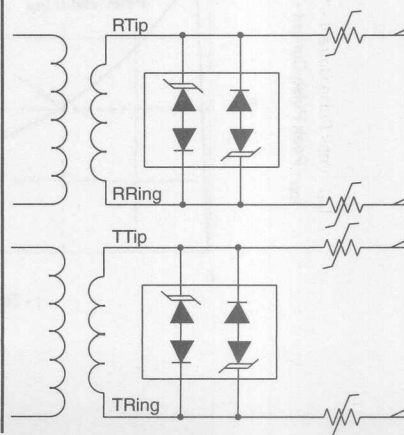


Optional 10 Pin VSIP Package



Pins 1 & 6 ground. Pins 2 & 3 connected externally. Pins 4 & 5 connected externally

TELECOMMUNICATION CIRCUIT LINE CARD APPLICATION



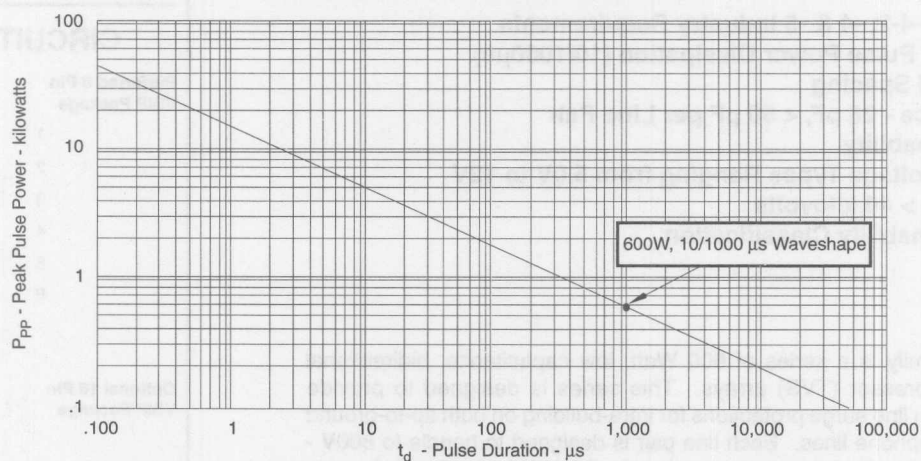
TVS
Arrays

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

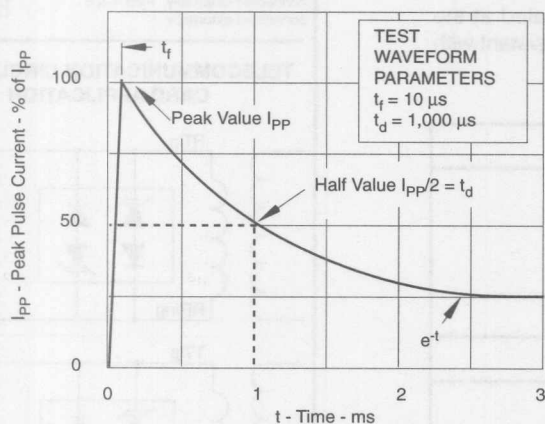
PROTEK PART NUMBER (See Note 1)	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 10$ A V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CAPACITANCE @ 0V, 1 MHz C pF
VSB06P05LCI	5.0	6.0	12.5	300	25
VSB06P6.5LCI	6.5	7.2	11.6	300	25
VSB06P12LCI	12.0	13.3	18.8	2.0	25

Note 1: Do not surge from pins 2 to 1, 1 to 3 or 4 to 6, 6 to 5. PIV typically greater than 100 Volts for each rectifier diode.

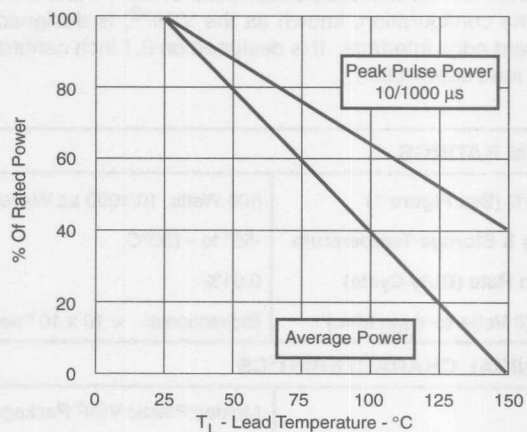
**FIGURE 1
PEAK PULSE POWER VS. PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



APPLICATIONS

- RS-232 & RS-423 Data Lines
- Telecommunication T/R Protection:
ISDN, ADSL, V.34/V.90, HDLC, T1/E1 & T3/E3
- Low & High Speed Data Lines: Ethernet,
Token Ring, USB, FireWire
- LAN/WAN Network Interface

FEATURES

- Meets IEC 1000-4-2, -4 & -5 Industry Requirements
- Series A: 500 Watts Peak Pulse Power Dissipation (8/20µs)
- Series B: 3,400 Watts Peak Pulse Power Dissipation (8/20µs)
- Available in 4 Voltage Ranges from 5.0V to 24V
- Variable Lead Spacing & Customer Designed Ground
- High Surge Capability & Low Capacitance Option
- ESD Protection > 40 kilovolts
- UL 94V-0 Flammability Classification

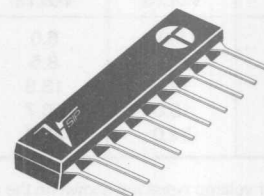
DESCRIPTION

The VSIP® (Variable Single In-line Package) is a multiple TVS array platform which facilitates the design and manufacture of application specific transient voltage suppressors to customer specific designs. The VSIP® allows for electrical variables with respect to voltage, power and capacitance together with variable physical characteristics for lead spacing and terminations.

The VSIP® is ideal for bread board designs, low to medium volume production runs and retrofit requirements. The VSIP® family consists of 2 basic series for board level protection. The primary characterization is to the industry standard 8/20µs waveform. Table 1 shows the series relationships to other standard waveforms.

MAXIMUM RATINGS	
P_{pp} @ 25°C (See Figure 1)	500 Watts & 3,500 Watts, 8/20 µs Waveshape
Operating & Storage Temperature	-55° to +150°C
Repetition Rate (Duty Cycle)	0.01%
t_{Clamping} (0 Volts to V_(BR) Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds Bidirectional: < 5 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded Plastic VSIP Package
Approximate Weight	1.5 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot over Pin 1

IEC 1000-4 COMPATIBLE



VSIP® PACKAGE

POWER MATRIX vs SERIES

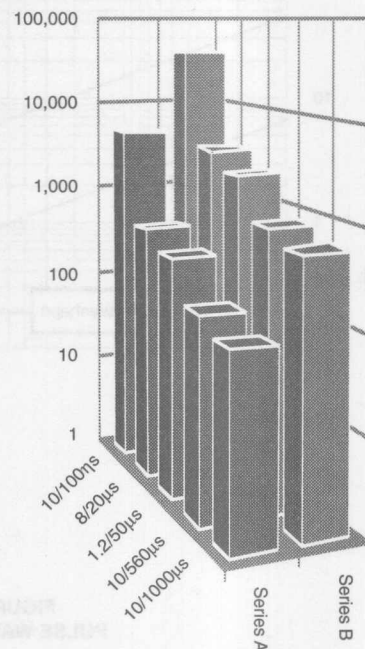


TABLE 1

Waveform	Series A	Series B
10/100µs	5,000 W	40,000 W
8/20µs	500 W	3,400 W
1.2/50µs	333 W	2,200 W
10/560µs	125 W	800 W
10/1000µs	90 W	600 W

PART NUMBER (Note 1 & 2)	STAND-OFF VOLTAGE (Note 3) V_{WM} VOLTS	BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	CLAMPING VOLTAGE (See Fig. 3) @ $I_P = 1$ A V_C VOLTS	CLAMPING VOLTAGE (See Fig. 3) @ $I_P = 10$ A V_C VOLTS	LEAKAGE CURRENT @ V_{WM} I_D μ A	PEAK PULSE CURRENT (See Fig. 3) I_{PP} AMPS	CLAMPING VOLTAGE (See Fig. 3) @ $I_{PP} = 1$ A V_C VOLTS	CLAMPING VOLTAGE (See Fig. 3) @ $I_P = 10$ A V_C VOLTS	LEAKAGE CURRENT @ V_{WM} I_D μ A	PEAK PULSE CURRENT (See Fig. 3) I_{PP} AMPS
5	5.0	6.0	9.8	12.5	100	40	8.6	9.1	300	300
8	8.0	8.5	13.4	16.6	10	28	10.9	12.0	200	258
12	12.0	13.3	19.5	22.7	1	20	17.0	18.8	2	184
15	15.0	16.7	24.4	28.5	1	15	21.4	23.6	2	147
24	24.0	26.7	39.1	45.6	1	10	34.2	37.8	2	93

Note 1: For voltage types not shown on the product data sheet, consult the factory.

Note 2: The low capacitance configuration values for each bidirectional line pair is as follows:

Series "A": $C = 25$ pF Series "B": $C = 100$ pF

Note 3: Forward Voltage (unidirectional configurations only):

Series "A": $V_F = 1.5V @ 200mA$ Series "B": $V_F = 1.5V @ 200mA$

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

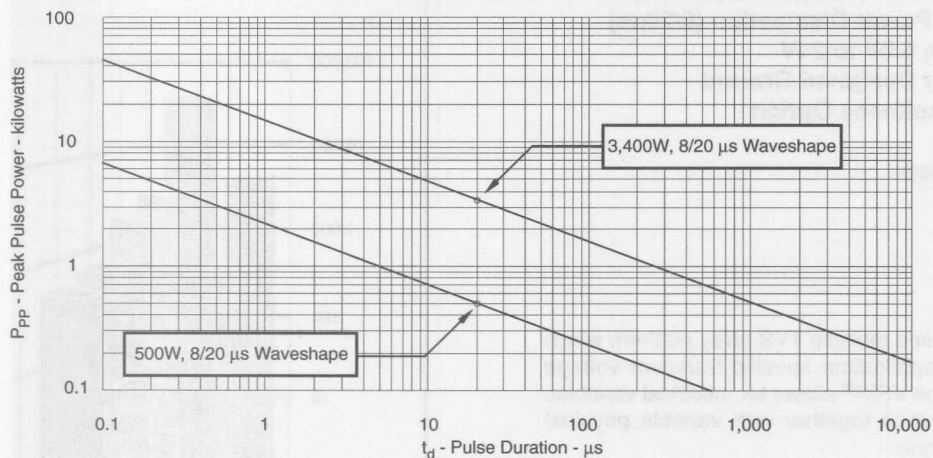


FIGURE 2
TYPICAL LOW CAPACITANCE CURVE

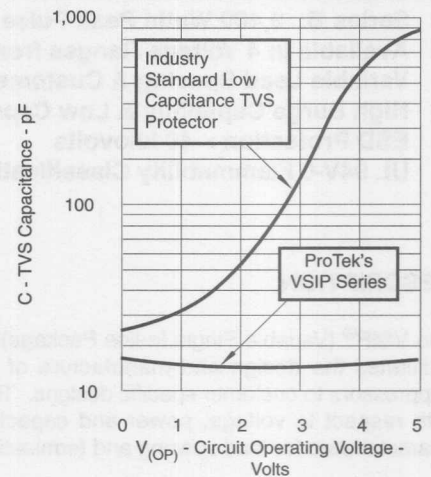


FIGURE 3
PULSE WAVEFORM

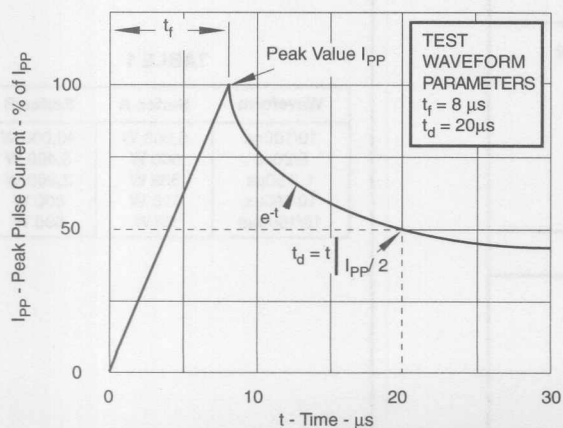
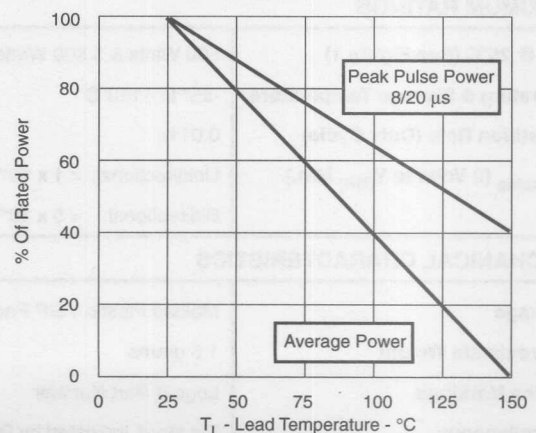


FIGURE 4
POWER DERATING CURVE





STANDARD PRODUCTS



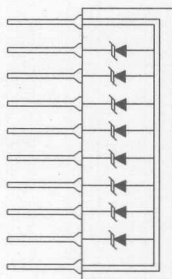
UNIDIRECTIONAL	BIDIRECTIONAL	LOW CAPACITANCE	LC* ISOLATED	NOTES
VS10P05	VS10P05C	VS10P05LC	VS10P05LCI	Series "A" devices are identified by the prefix "VS". Series "B" devices are identified by the prefix "VSB". All standard devices are 10 pin with the two outside pins being ground. It is recommended that an additional ground pin be added for every four lines of protection. Contact the factory for the part number of other voltage types.
VS10P08	VS10P08C	VS10P08LC	VS10P08LCI	
VS10P12	VS10P12C	VS10P12LC	VS10P12LCI	
VS10P15	VS10P15C	VS10P15LC	VS10P15LCI	
VS10P24	VS10P24C	VS10P24LC	VS10P24LCI	
VSB10P05	VSB10P05C	VSB10P05LC	VSB10P05LCI	LC* = Low Capacitance
VSB10P08	VSB10P08C	VSB10P08LC	VSB10P08LCI	
VSB10P12	VSB10P12C	VSB10P12LC	VSB10P12LCI	
VSB10P15	VSB10P15C	VSB10P15LC	VSB10P15LCI	
VSB10P24	VSB10P24C	VSB10P24LC	VSB10P24LCI	

LC* = Low Capacitance

TVS
ARRAYS

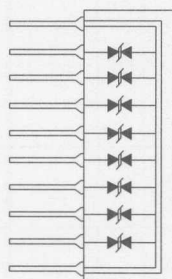
UNIDIRECTIONAL

Standard
Configuration



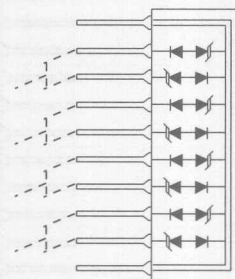
BIDIRECTIONAL

Standard
Configuration

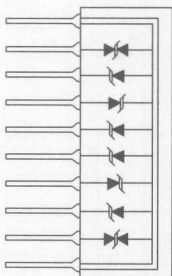


LOW CAPACITANCE

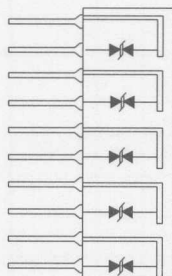
Standard
Configuration



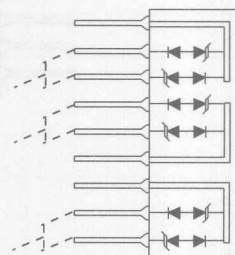
Mixed
Configuration
+ 5.0V
- 5.0V
+ 8.0V
± 12.0V



Line-to-Line
Isolated

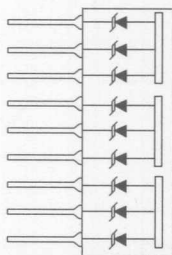


Isolated
Low Crosstalk



Bidirectional
(Line-to-Line
&
Line-to-Ground)

3 Individual
Circuits





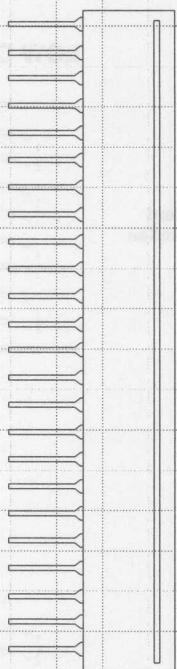
WORKSHEET



SERIES		TVS TYPE	VOLTAGE	DIRECTIONS
A	500 Watts	D Cathode	i.e.	Specify each pin by the codes as shown in the adjacent table. Example: 2AD10 is 500W, Cathode-out, 10V TVS located at pin 2. 1G is a ground connection located at pin 1. 3BF24 is a 3,400W, Bidirectional, 24V TVS located at pin 3. As an option, the appropriate symbol, voltages and series can be drawn at each pin location.
B	3,400 Watts	E Anode	5	
G	Ground	F Bidirectional	8	
		H - Low Cap.	10	
		K + Low Cap.	15	
			etc...	

100 mil Centers

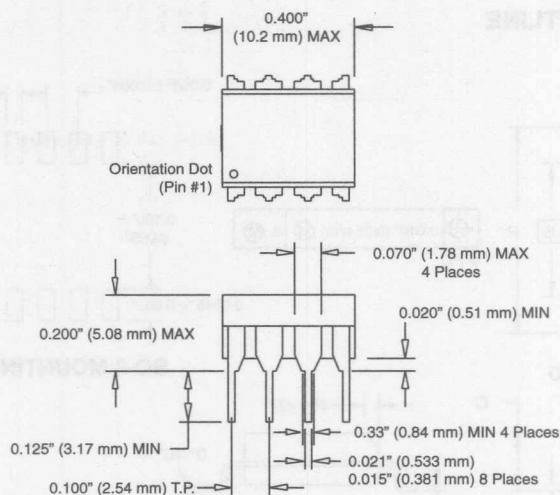
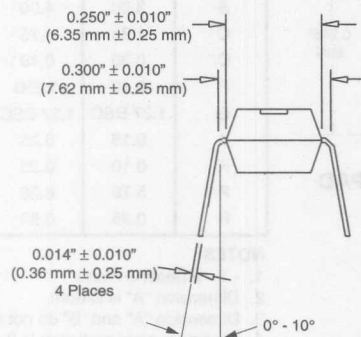
PIN 1



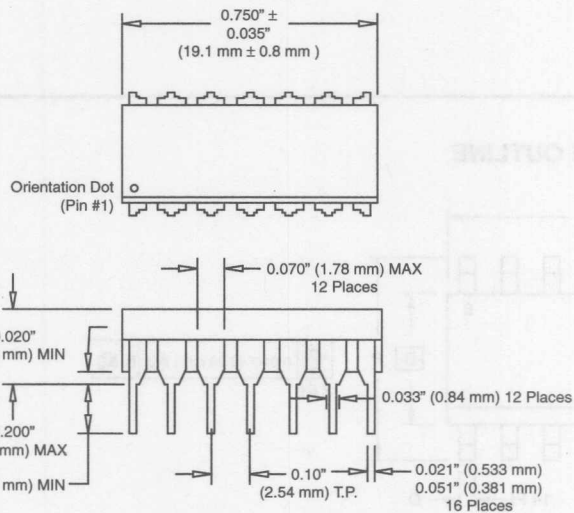
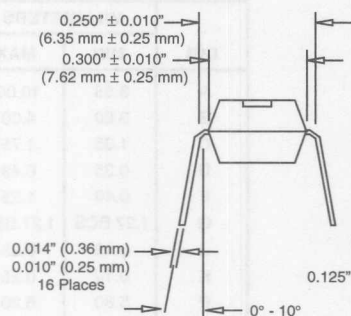
It is recommended that devices on 0.100 inch centers be limited to a pin count of no greater than 24 and no greater than 12 for devices on 0.200 inch centers. It is recommended that a ground pin be added for every four (4) lines of protection. This is to minimize the lead inductance for fast rise transient pulses such as ESD.



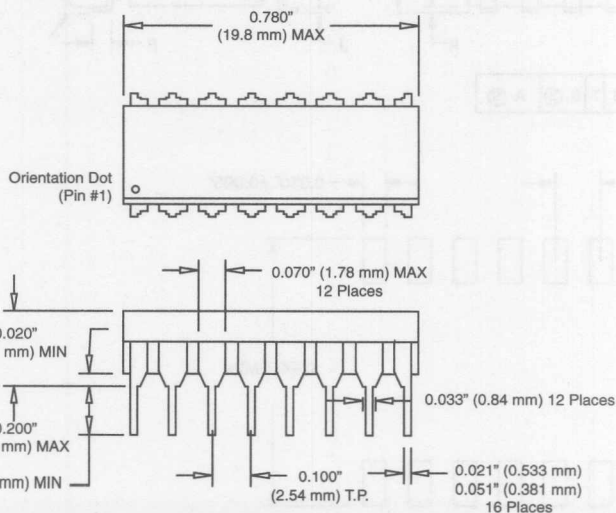
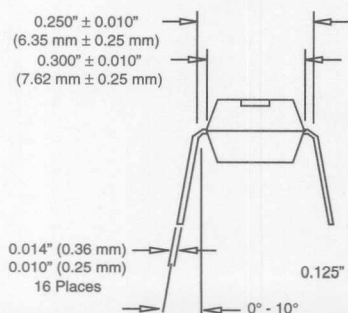
8 PIN PLASTIC DIP

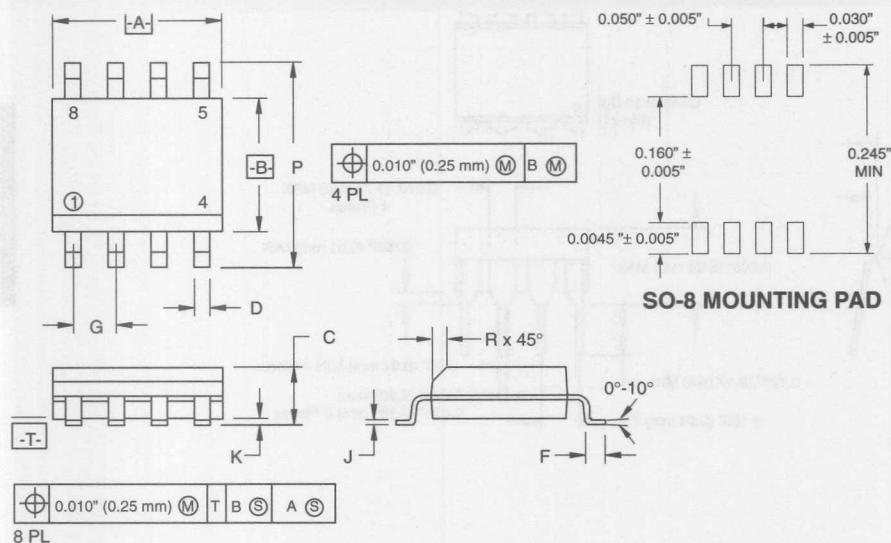


14 PIN PLASTIC DIP



16 PIN PLASTIC DIP



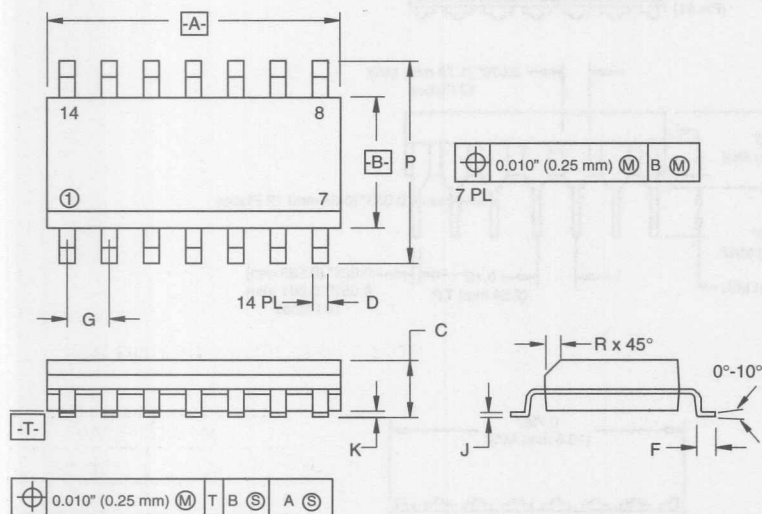


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.250	0.016	0.049
G	1.27 BSC	1.27 BSC	0.05 BSC	0.05 BSC
J	0.18	0.25	0.007	0.009
K	0.10	0.25	0.004	0.008
P	5.78	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

NOTES:

1. - T - = Seating Plane
2. Dimension "A" is Datum.
3. Dimension "A" and "B" do not include mold protusion.
4. Maximum mold protusion is 0.15" (0.006 mm) per side.
5. Dimensioning and tolerances per ANSI Y14.5M, 1982.

SO-14 PACKAGE OUTLINE



SO-14 PACKAGE DIMENSIONS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.55	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BCS	1.27 BSC	0.05 BSC	0.05 BSC
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

NOTES:

1. - T - = Seating Plane
2. Dimension "A" is Datum.
3. Dimension "A" and "B" do not include mold protusion.
4. Maximum mold protusion is 0.15" (0.006 mm) per side.
5. Dimensioning and tolerances per ANSI Y14.5M, 1992.

SO-16 PACKAGE DIMENSIONS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.80	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC	1.27 BSC	0.05 BSC	0.05 BSC
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

SO-16L (Wide Body) PACKAGE DIMENSIONS

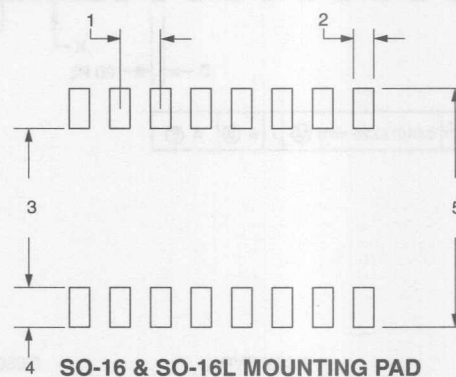
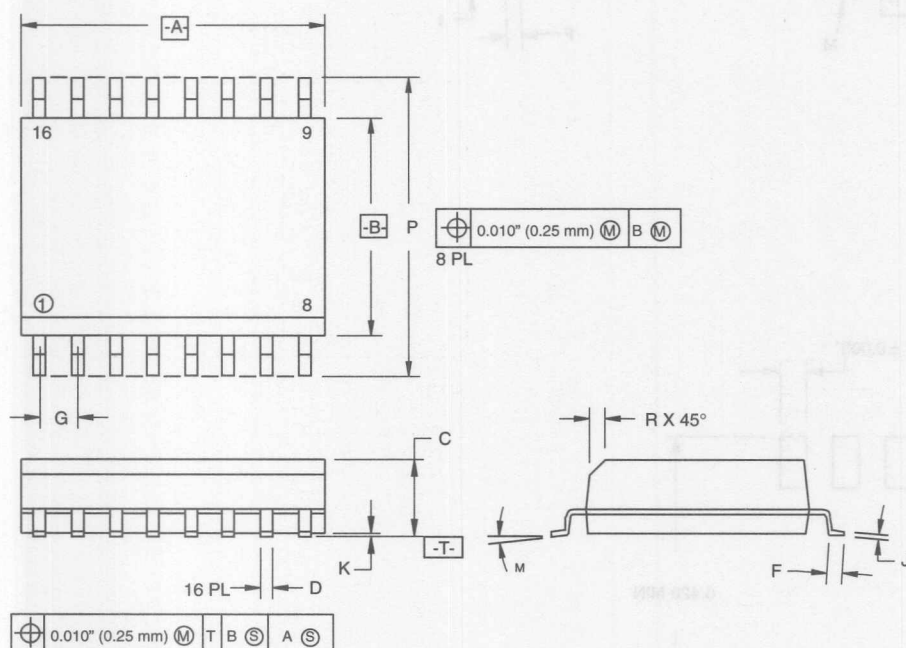
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.15	10.45	0.400	0.411
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC	1.27 BSC	0.05 BSC	0.05 BSC
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029

NOTES:

1. - T - = Seating Plane
2. Dimension "A" is Datum
3. Dimension "A" and "B" do not include mold protusion.
4. Dimensioning and tolerances per ANSI Y14.5M, 1982.

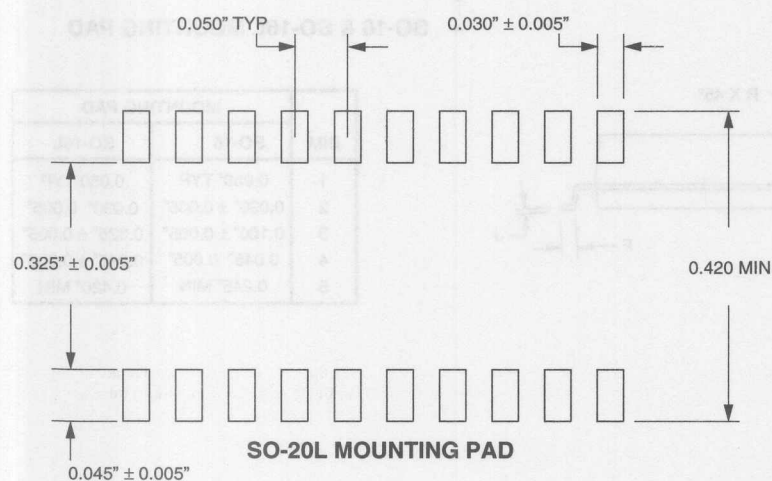
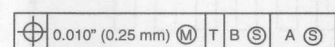
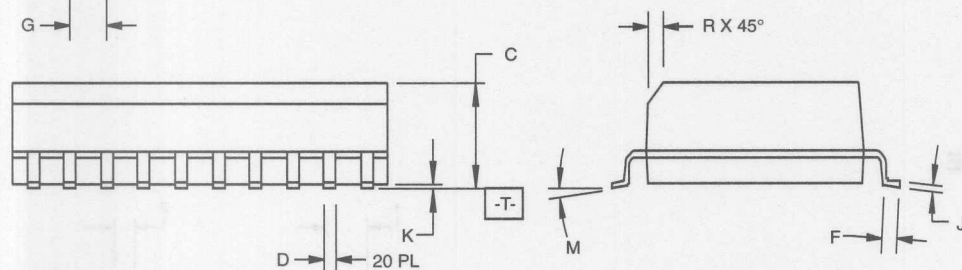
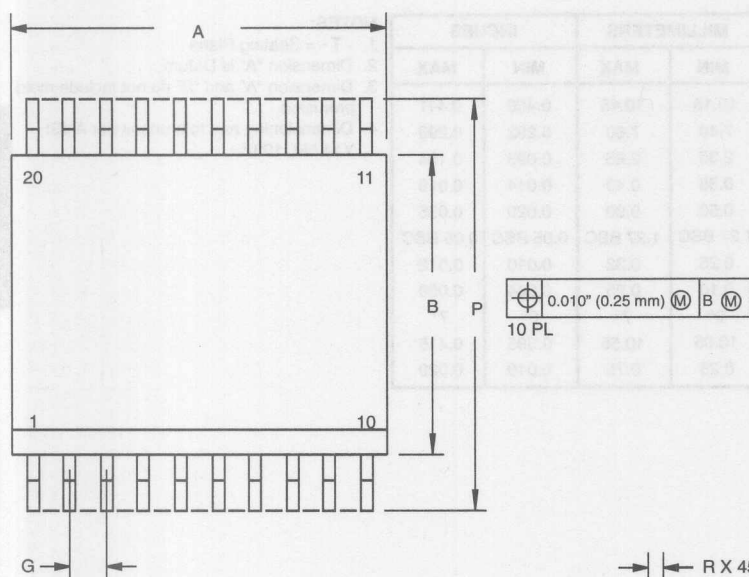
TVS
ARRAYS

SO-16 & SO-16L PACKAGE OUTLINE



DIM	MOUNTING PAD	
	SO-16	SO-16L
1	0.050" TYP	0.050 TYP
2	0.030" ± 0.005"	0.030" ± 0.005"
3	0.160" ± 0.005"	0.325" ± 0.005"
4	0.045" ± 0.005"	0.045" ± 0.005"
5	0.245" MIN	0.420" MIN

SO-20L PACKAGE OUTLINE



SO-20L PACKAGE DIMENSIONS (WIDE BODY)

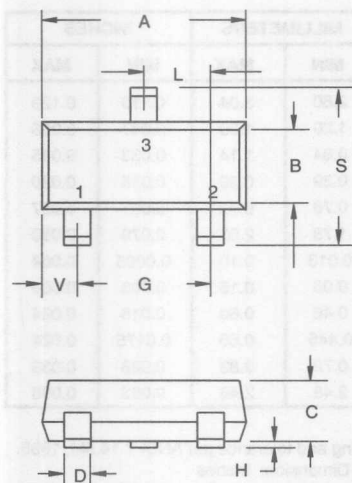
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.65	12.95	0.499	0.510
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC	1.27 BSC	0.05 BSC	0.05 BSC
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
	0.25	0.75	0.010	0.029

NOTES:

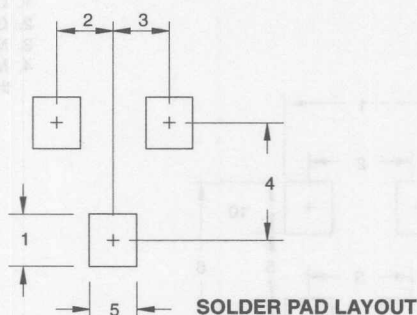
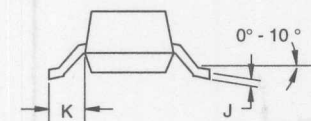
1. - T - = Seating Plane
2. Dimension "A" is Datum
3. Dimension "A" and "B" do not include mold protrusion.
4. Maximum mold protrusion is 0.15" (0.006 mm).
5. Dimensioning and tolerances per ANSI Y14.5M, 1982.



SOT-23 PACKAGE OUTLINE



DIM	TYPICAL	
	Millimeters	Inches
1	0.85	0.033
2	0.95	0.037
3	0.95	0.037
4	2.00	0.079
5	0.85	0.033



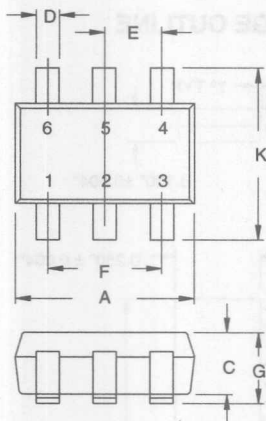
SOT-23 PACKAGE DIMENSIONS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.04	0.1102	0.1197
B	1.20	1.40	0.0472	0.0551
C	0.89	1.11	0.0350	0.0440
D	0.37	0.50	0.0150	0.0200
G	1.78	2.04	0.0701	0.0807
H	0.013	0.100	0.0005	0.0040
J	0.085	0.177	0.0034	0.0070
K	0.45	0.60	0.0180	0.0236
L	0.89	1.02	0.0350	0.0401
S	2.10	2.50	0.0830	0.0984
V	0.45	0.60	0.0177	0.0236

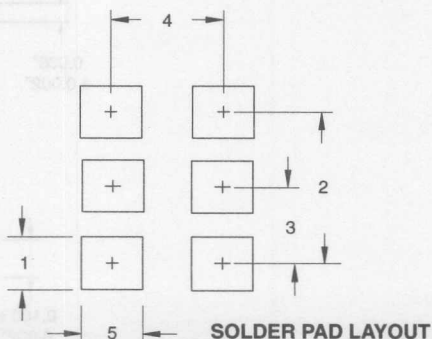
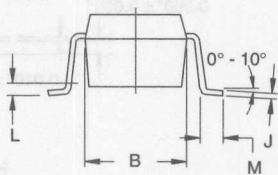
NOTES:

1. Dimensioning and tolerance per ANSI Y 14.5M, 1985.
2. Controlling Dimension: Inches
3. Maximum lead thickness includes lead finish thickness.
4. Minimum lead thickness is the minimum thickness of the base material.
4. Pin 3 is the cathode (Unidirectional only).

SOT-23-6 PACKAGE OUTLINE



DIM	TYPICAL	
	Millimeters	Inches
1	1.00	0.039
2	1.90	0.074
3	0.95	0.037
4	2.40	0.094
5	1.00	0.039



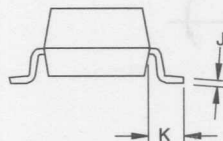
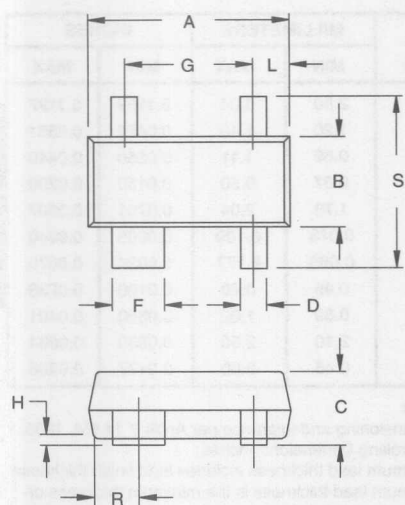
SOT-23-6 PACKAGE DIMENSIONS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.05	0.110	0.120
B	1.50	1.75	0.059	0.070
C	0.90	1.30	0.036	0.051
D	0.35	0.50	0.014	0.020
E	0.85	1.05	0.033	0.040
F	1.70	2.10	0.067	0.083
G	0.90	1.45	0.036	0.057
J	0.090	0.20	0.0035	0.008
K	2.60	3.00	0.102	0.118
L	0.20 TYP	0.20 TYP	0.007 TYP	0.007 TYP
M	0.35	0.55	0.014	0.022

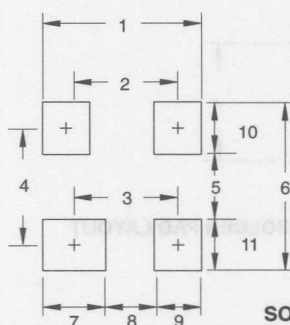
NOTES:

1. Dimensioning and tolerance per ANSI Y 14.5M, 1985.
2. Controlling Dimension: Inches
3. Maximum lead thickness includes lead finish thickness.
4. Minimum lead thickness is the minimum thickness of the base material.

SOT-143 PACKAGE OUTLINE



DIM	TYPICAL	
	Millimeters	Inches
1	2.85	0.112
2	2.00	0.079
3	1.80	0.071
4	1.90	0.075
5	1.05	0.041
6	2.75	0.108
7	1.20	0.047
8	0.80	0.031
9	0.85	0.033
10	0.85	0.033
11	0.85	0.033



SOLDER PAD LAYOUT

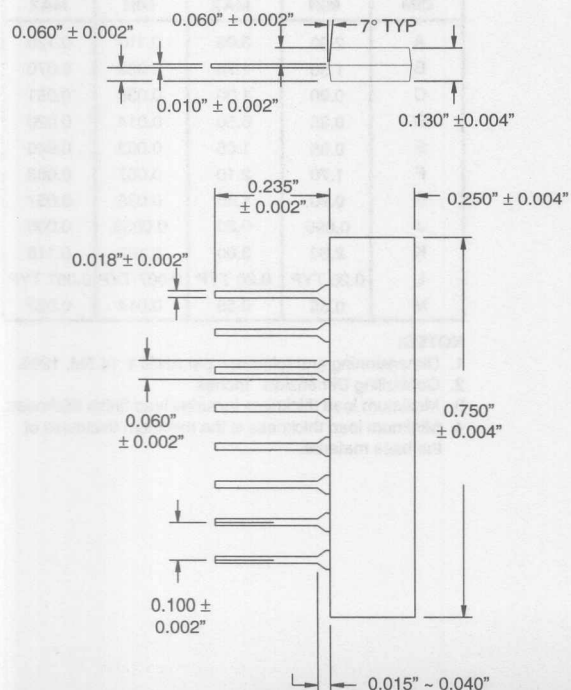
SOT-143 PACKAGE DIMENSIONS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.80	3.04	0.110	0.120
B	1.20	1.39	0.047	0.055
C	0.84	1.14	0.033	0.045
D	0.39	0.50	0.015	0.020
F	0.79	0.93	0.031	0.037
G	1.78	2.03	0.070	0.080
H	0.013	0.10	0.0005	0.004
J	0.08	0.15	0.003	0.006
K	0.46	0.60	0.018	0.024
L	0.445	0.60	0.0175	0.024
R	0.72	0.83	0.028	0.033
S	2.48	2.48	0.083	0.098

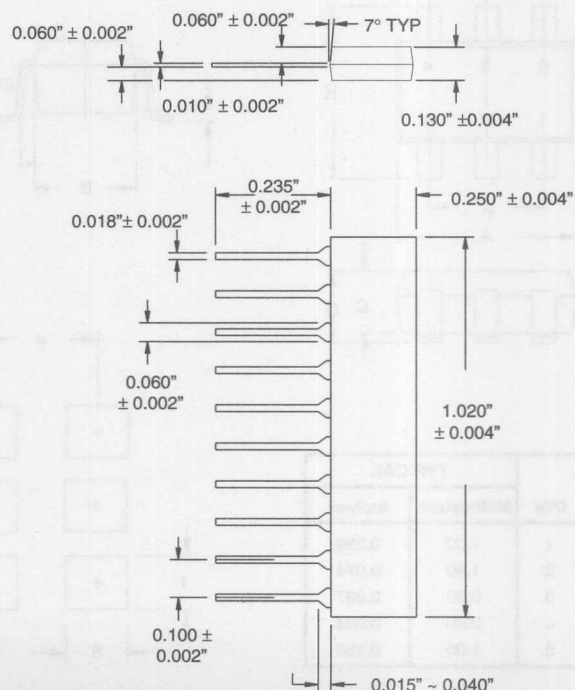
NOTES:

1. Dimensioning and tolerance per ANSI Y 14.5M, 1985.
2. Controlling Dimension: Inches
3. Maximum lead thickness includes lead finish thickness.
4. Minimum lead thickness is the minimum thickness of the base material.

VSB06 PACKAGE OUTLINE



VSIP PACKAGE OUTLINE



SECTION 3 Rail Clamp/ Steering Diode Components

Contents

Page

PMAD Series:	14 Pin DIP Steering Diode Arrays (Rail Clamp)	3-3
PMMAD Series:	14 Pin SO-14 Steering Diode Arrays (Rail Clamp)	3-5
PMMAD1108:	16 Pin SO-16 Steering Diode Array (Rail Clamp)	3-7
PSRDA70-4:	8 Pin SO-8 Low Capacitance Steering Diode Arrays (Rail Clamp) - 4 Lines	3-9

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SPECIFICATIONS: ProTek reserves the right to change the electrical and or mechanical characteristics described herein without notice (except JEDEC).

DESIGN CHANGES: ProTek reserves the right to discontinue product lines without notice, and that the final judgement concerning selection and specifications is the buyer's and that in furnishing engineering and technical assistance, ProTek assumes no responsibility with respect to the selection or specifications of such products.

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8 Pin SO-8 Low Capacitance Steering Diode Array (Rail Clamp) - 4 Lines

14 Pin DIP Steering Diode Array (Rail Clamp)

14 Pin SO-14 Steering Diode Array (Rail Clamp)

18 Pin SO-18 Steering Diode Array (Rail Clamp)

Contents

PMAD Series

PMAD Series

PMAD Series

PMAD Series

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STEERING DIODE ARRAYS (RAIL CLAMP)

APPLICATIONS

- High Frequency Data Lines
- RS-232 & RS-422 Interface Networks
- 10 Base T Networks
- LAN/ WAN
- Computer I/O Ports

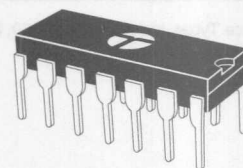
FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- Designed for Rail Clamp Protection
- ESD Protection > 40 kilovolts
- Low Capacitance - 5 pF
- Working Voltage > 50 Volts
- UL 94V-0 Flammability Classification
- Available in Standard 14 Pin Dual-in-Line Package

DESCRIPTION

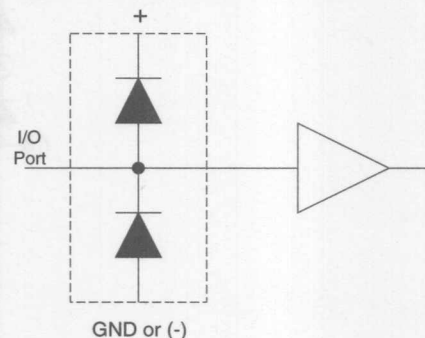
This series is designed with discrete diodes for complete isolation. Each diode can be individually tested according to the electrical characteristics. For transient voltage protection, two diodes are configured in series with the anode of one connected to the cathode of the other diode (See Rail Clamp Circuit).

IEC 1000-4 COMPATIBLE



14 PIN DIP PACKAGE

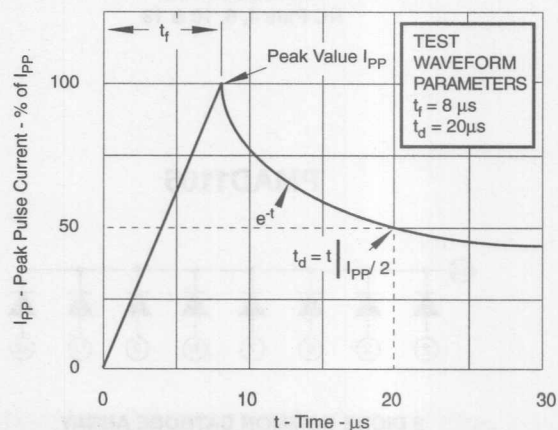
RAIL CLAMP CIRCUIT



SEE DIAGRAMS ON FOLLOWING PAGE.

Rail Clamp
Steering Diodes

**FIGURE 1
PULSE WAVE FORM**



MAXIMUM RATINGS @ 25°C Ambient Temperature (unless specified)	
Continuous Power Dissipation	500mW
Operating & Storage Temperature	-55° to +150°C
Continuous Forward Current	400mA
MECHANICAL CHARACTERISTICS	
Package	Molded 14 Pin DIP, Page 2-71 for dimensions
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.15 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

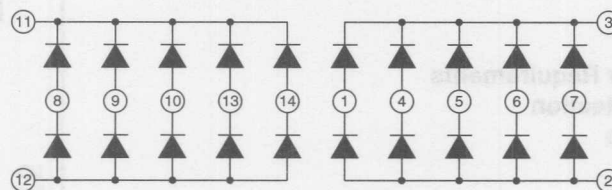
PROTEK PART NUMBER	REPETITIVE PEAK REVERSE VOLTAGE @ 10 μ A V_{RRM} VOLTS	REVERSE LEAKAGE CURRENT @ 40 V I_{RM} μ A	MAXIMUM FORWARD VOLTAGE @ 100 mA V_F VOLTS	FORWARD PEAK PULSE CURRENT (See Fig. 1) @ 8/20 μ s I_{FM} AMPS	MAXIMUM CAPACITANCE @ 4 V, 1 MHz C pF
See Note 1	50	0.1	1.2	40	5

Note 1: Device Types Include: PMAD130, PMAD1103, PMAD1105, PMAD1107 and PMAD1109. Electrical characteristics applies to all device types.

CIRCUIT DIAGRAMS

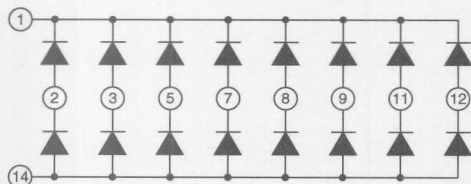
(See Page 2-71 for 14 Pin DIP Package Outline Dimensions)

PMAD130



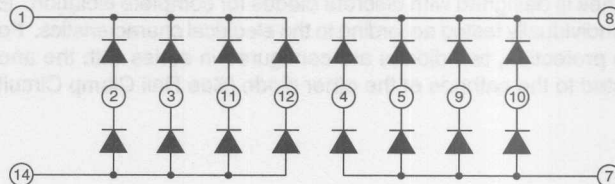
DUAL 10 DIODE ARRAY

PMAD1103



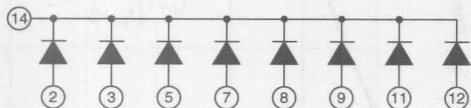
16 DIODE ARRAY
NC Pins 4, 6, 10 & 13

PMAD1107



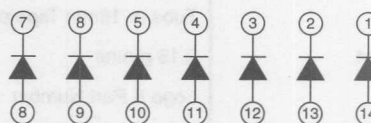
DUAL 8 DIODE ARRAY
NC Pins 6 & 13

PMAD1105



8 DIODE COMMON CATHODE ARRAY
NC Pins 1, 4, 6, 10 & 13

PMAD1109



7 ISOLATED DIODE ARRAY
(Independent)



STEERING DIODE ARRAYS (RAIL CLAMP)

APPLICATIONS

- High Frequency Data Lines
- RS-232 & RS-422 Interface Networks
- 10 Base T Networks
- LAN/ WAN
- Computer I/O Ports

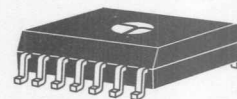
FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- Designed for Rail Clamp Protection
- ESD Protection > 40 kilovolts
- Low Capacitance - 5 pF
- Working Voltage > 50 Volts
- UL 94V-0 Flammability Classification
- Available in Standard SO-14 Surface Mount Package

DESCRIPTION

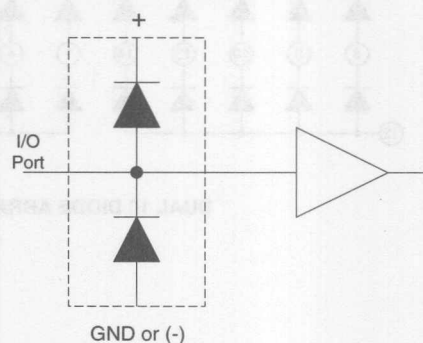
This series is designed with discrete diodes for complete isolation. Each diode can be individually tested according to the electrical characteristics. For transient voltage protection, two diodes are configured in series with the anode of one connected to the cathode of the other diode (See Rail Clamp Circuit).

IEC 1000-4 COMPATIBLE



SO-14 PACKAGE

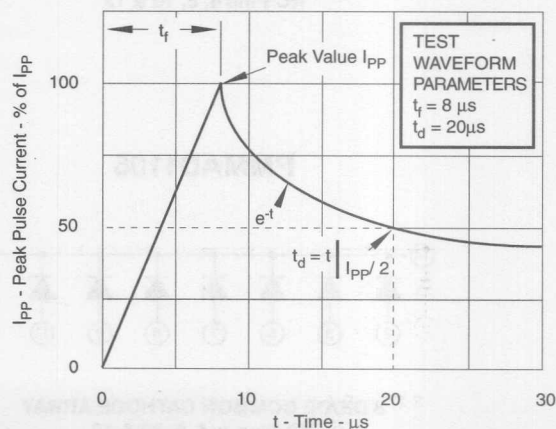
RAIL CLAMP CIRCUIT



SEE DIAGRAMS ON FOLLOWING PAGE.

Rail Clamp
Steering Diodes

**FIGURE 1
PULSE WAVE FORM**



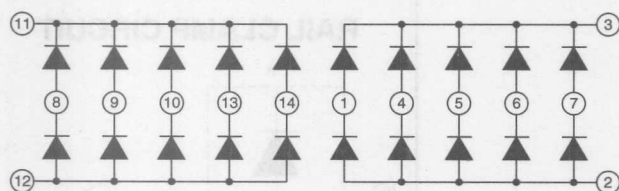
MAXIMUM RATINGS @ 25°C Ambient Temperature (unless specified)	
Continuous Power Dissipation	500mW
Operating & Storage Temperature	-55° to +150°C
Continuous Forward Current	400mA
MECHANICAL CHARACTERISTICS	
Package	Molded SO-14 Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.15 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

	@ 10 μ A V_{RRM} VOLTS	@ 40 V I_{RM} μ A	@ 100 mA V_F VOLTS	(See Fig. 1) @ 8/20 μ s I_{FM} AMPS	@ 4 V, 1 MHz C pF
See Note 1	50	0.1	1.2	40	5

Note 1: Device Types Include: PMMAD130, PMMAD1103, PMMAD1105, PMMAD1106, PMMAD1107 and PMMAD1109. Electrical characteristics applies to all device types.

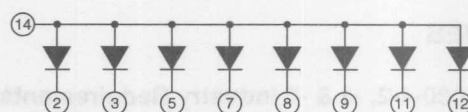
CIRCUIT DIAGRAM

PMMAD130



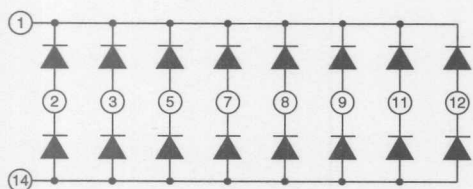
DUAL 10 DIODE ARRAY

PMMAD1106



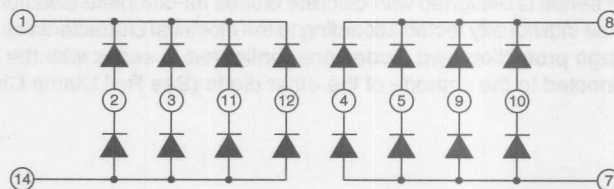
8 DIODE COMMON ANODE ARRAY
NC Pin 1, 4, 6, 10 & 13

PMMAD1103



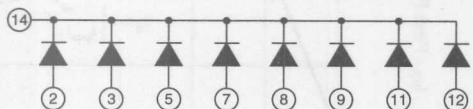
14 DIODE ARRAY
NC Pins 4, 6, 10 & 13

PMMAD1107



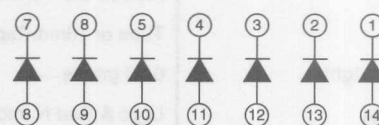
DUAL 8 DIODE ARRAY
NC Pins 6 & 13

PMMAD1105



8 DIODE COMMON CATHODE ARRAY
NC Pins 1, 4, 6, 10 & 13

PMMAD1109



7 ISOLATED DIODE ARRAY
(Independent)

STEERING DIODE ARRAY (RAIL CLAMP)

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	REPETITIVE PEAK REVERSE VOLTAGE @ 10 μ A V_{RRM} VOLTS	REVERSE LEAKAGE CURRENT @ 40 V I_{RM} μ A	FORWARD PEAK PULSE CURRENT (See Fig. 1) @ 8/20 μ s I_{Fm} AMPS	MAXIMUM FORWARD VOLTAGE @ 100 mA V_F VOLTS	MAXIMUM CAPACITANCE @ 4 V, 1 MHz C pF
PPMAD1108	50	0.1	40	1.2	5

APPLICATIONS

- High Frequency Data Lines
- RS-232 & RS-422 Interface Networks
- 10 Base T Networks
- LAN/ WAN
- Computer I/O Ports

FEATURES

- IEC 1000-4-2, -4 & -5 Industry Requirements
- Eight (8) Individual Steering Diodes
- Designed for Rail Clamp Protection
- ESD Protection > 40 kilovolts
- Low Capacitance - 5 pF
- Working Voltage > 50 Volts
- UL 94V-0 Flammability Classification
- Available in Standard SO-16 Surface Mount Package

DESCRIPTION

This device is designed with discrete diodes for complete isolation. Each diode can be individually tested according to the electrical characteristics. For transient voltage protection, two diodes are configured in series with the anode of one connected to the cathode of the other diode (See Rail Clamp Circuit).

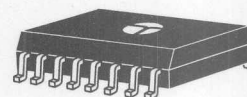
MAXIMUM RATINGS

Continuous Power Dissipation	500mW
Operating & Storage Temperature	-55° to +150°C
Continuous Forward Current	400mA

MECHANICAL CHARACTERISTICS

Package	Molded SO-16 Surface Mount Package
Packaging	Tube or 16mm Tape per EIA 481
Approximate Weight	0.15 grams
Device Markings	Logo & Part Number
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

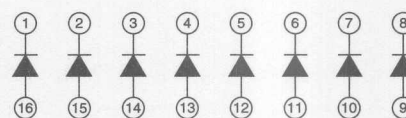
IEC 1000-4 COMPATIBLE



Rail Clamp
Steering Diodes

SO-16 PACKAGE

CIRCUIT DIAGRAM



PMMAD1108
8 ISOLATED DIODE ARRAY

RAIL CLAMP CIRCUIT

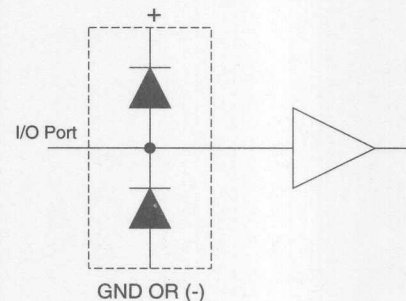
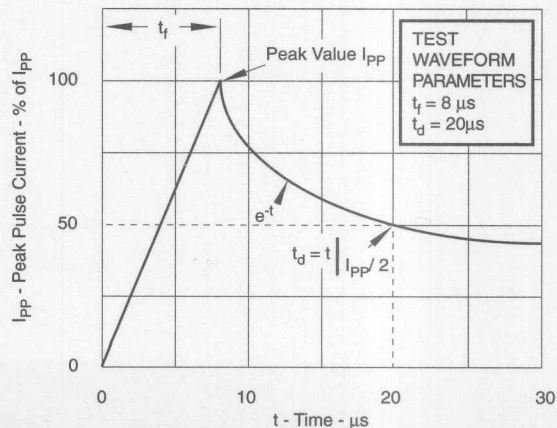


FIGURE 1
PULSE WAVE FORM



5090 10/98

HIGH SPEED STEERING DIODE ARRAY (RAIL CLAMP)

APPLICATIONS

- RS-422 & RS-485 Interface Protection
- USB Power & Data Line Protection
- LAN/WAN Interface Protection
- Microcontroller Interface Protection
- 10 Base T Networks

FEATURES

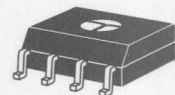
- IEC 1000-4-2, -4 & -5 Industry Requirements
- ESD Protection > 40 kilovolts
- Low Capacitance - 15 pF
- Protects up to Four (4) I/O Ports
- Available in a Standard SO-8 Package
- UL 94V-0 Flammability Classification

DESCRIPTION

The PSRDA70-4 is a low capacitance steering diode/rail clamp configuration designed for complete isolation. This device can be used to protect data lines from the effects of Electrostatic Discharge (ESD), Electrically Fast Transients (EFT) and induced lightning.

The PSRDA70-4 is offered in a standard SO-8 surface mount package. This device can be used to protect four (4) data or I/O port lines and is suitable for use on high speed interfaces.

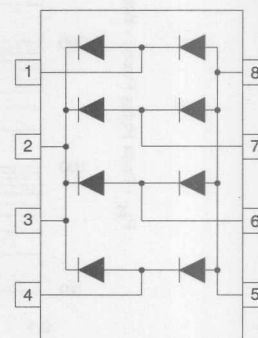
IEC 1000-4 COMPATIBLE



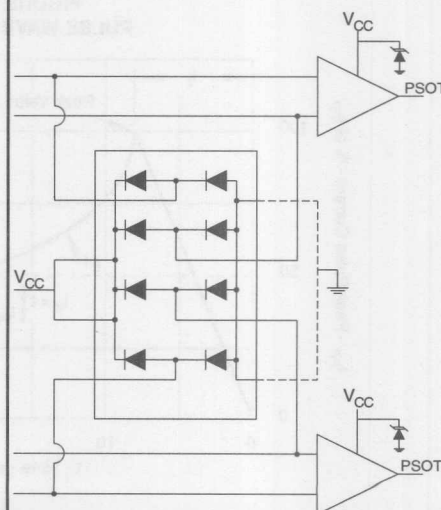
Rail Clamp
Steering Diodes

SO-8 PACKAGE

CIRCUIT DIAGRAM



HIGH SPEED DATA LINE APPLICATION



MAXIMUM RATINGS

Continuous Power Dissipation	500 milliwatts
Operating & Storage Temperature	-55° to +150°C
Forward Surge Current (8/20 μ s)	24 Amps
Peak Rectifier V_{RRM}	70 Volts (DC Operating Voltage)
Thermal Resistance $R_{\theta ja}$	170 °C/W
Thermal Resistance $R_{\theta jl}$	60 °C/W

MECHANICAL CHARACTERISTICS

Package	Molded SO-8 Surface Mount Package
Packaging	Tube or 12mm Tape per EIA 481
Approximate Weight	0.1 grams
Device Markings	Logo & Marking Code
Miscellaneous	Pin No. 1 Indicated by Dot on Top of Package

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK TYPE NUMBER	DEVICE MARKING CODE	REPETITIVE PEAK REVERSE VOLTAGE V_{RRM} VOLTS	MAXIMUM FORWARD VOLTAGE @ $I_F = 100\text{ mA}$ V_F VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ 8/20 μs I_{FM} AMPS	MAXIMUM LEAKAGE CURRENT @ V_{RRM} I_R μA	MAXIMUM CAPACITANCE (See Note 1) C pF
PSRDA70-4	PRG	70	1.1	24	5	15

FIGURE 1
PEAK PULSE POWER VS PULSE TIME

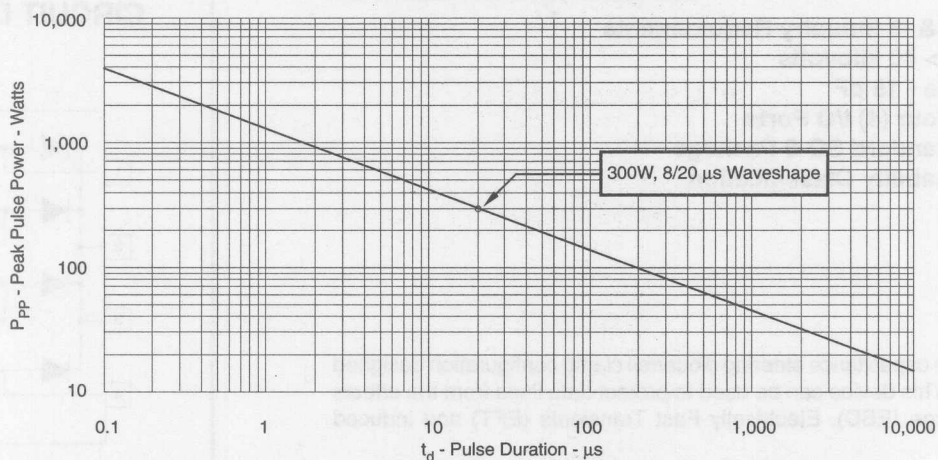


FIGURE 2
PULSE WAVE FORM

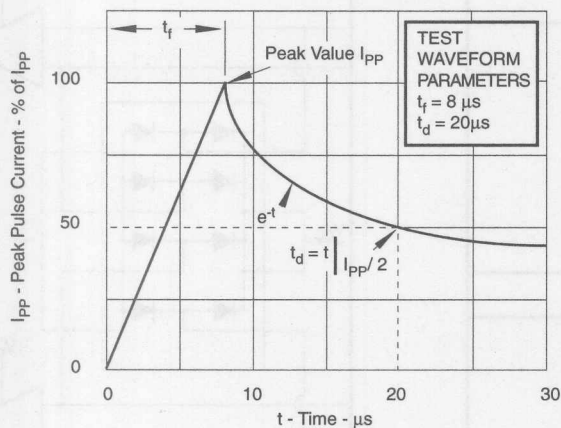
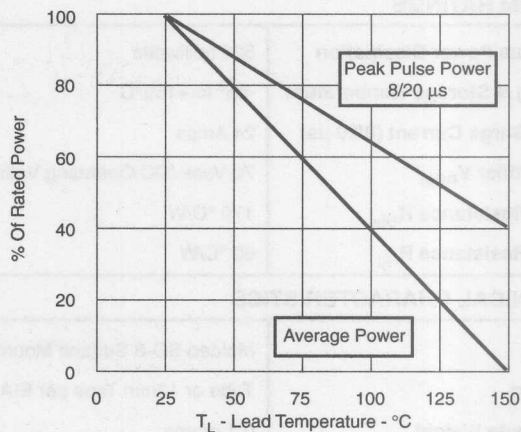


FIGURE 3
POWER DERATING CURVE



SECTION 4 Discrete Transient Voltage Suppressor Components

<u>Contents</u>		<u>Page</u>
15KPA Series:	High Current Thru-Hole Discrete TVS Diode	4-3
PP-SM Series:	DO-214AA Thyristor Surge Suppressor	4-5
SMDJ Series:	DO-214AB High Current Discrete TVS Diode	4-9

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DESIGN CHANGES: ProTek reserves the right to discontinue product lines without notice, and that the final judgement concerning selection and specifications is the buyer's and that in furnishing engineering and technical assistance, ProTek assumes no responsibility with respect to the selection or specifications of such products.

SECTION 4 Discrete Transient Voltage Suppressors Components

Page	Contents
4-3	High Current Transient Voltage Suppressors
4-4	DO-214AA Transient Voltage Suppressors
4-5	DO-214AB High Current Transient Voltage Suppressors

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HIGH CURRENT THRU-HOLE DISCRETE TVS DIODE

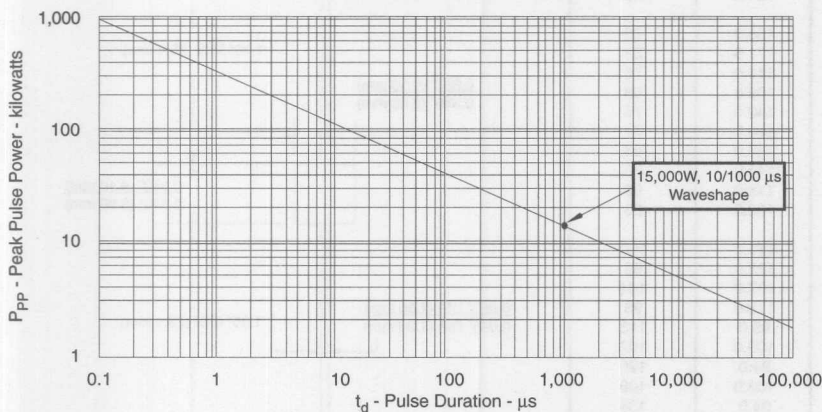
APPLICATIONS

- Relay Drives
- Motor (Start/Stop) Back EMF Protection
- Module Lightning Protection

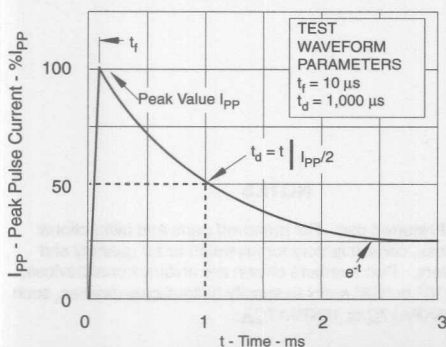
FEATURES

- 15,000 Watts Peak Pulse Power Dissipation (10/1000 μ s)
- Available in Numerous Voltage Types Ranging from 17.0V to 280V
- Easy Mounting to Printed Circuit Boards
- UL 94V-0 Flammability Classification

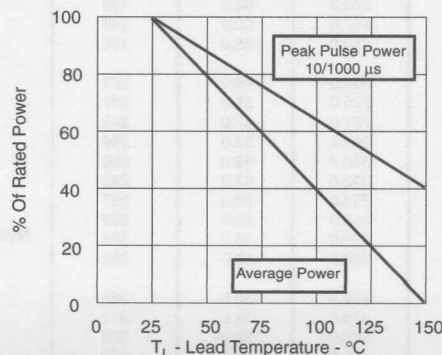
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



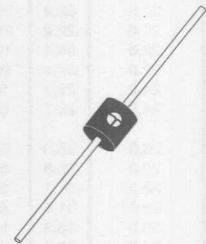
**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



15,000 WATTS



MAXIMUM RATINGS

- 15,000 Watts Peak Pulse Dissipation @25°C (See Figure 1)
- Operating & Storage Temperature: -55°C to +150°C
- Forward Surge Rating: 100A, 1/20 second @25°C
- Steady State Power Dissipation: 7.0W $T_A = 25^\circ C$
- Repetition Rate (Duty Cycle): 0.05%
- $t_{Clamping}$ (0 Volts to V_{BR} min):
Unidirectional $< 1 \times 10^{-12}$ seconds
Bidirectional $< 10 \times 10^{-9}$ seconds

MECHANICAL CHARACTERISTICS

- Package: Molded Case
- Approximate Weight: 13 grams
- Positive Terminal Marked with Band (Unidirectional)
- Body Marked with Logo & Part No.

DESCRIPTION

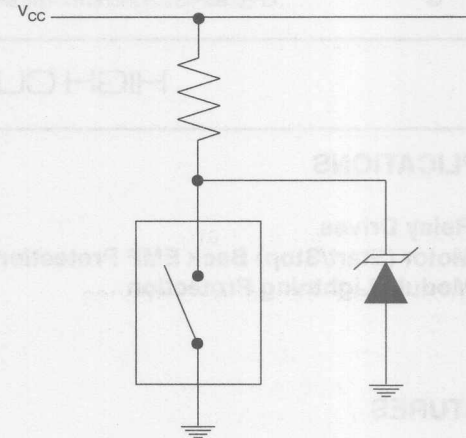
The 15KPA family is a series of discrete 15,000 Watt, silicon transient voltage suppressor diodes designed for use in applications where large voltage transients can permanently damage voltage sensitive components and equipment.

The 15KPA series has a peak pulse power (P_{PP}) rating of 15,000 Watts for an 10/1000 μ s waveshape. This series is available in voltages ranging from 17.0 Volts to 280 Volts with 5 percent and 10 percent tolerances. Both tolerances are referenced to the power supply output or operating voltage level.

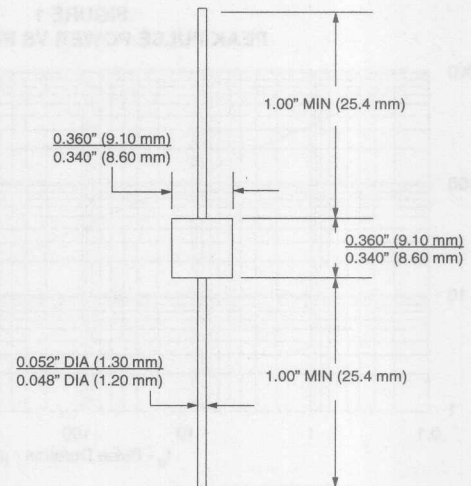
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1 & Note 2)	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	BREAKDOWN VOLTAGE		MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_P = 1 A$ V_C VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ I_{PP} I_{PPM} AMPS	MAXIMUM TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
		MIN $V_{(BR)}$ VOLTS	@ I_T mA				
15KPA17	17.0	18.9	50	5000	32.3	464.0	19
15KPA17A	17.0	18.9	50	5000	29.3	512.0	17
15KPA18	18.0	20.0	50	5000	34.2	439.0	20
15KPA18A	18.0	20.0	50	5000	30.9	485.0	18
P 15KPA20	20.0	22.2	20	1500	37.9	396.0	24
P 15KPA20A	20.0	22.2	20	1500	34.3	437.0	21
15KPA22	22.0	24.4	10	500	41.1	365.0	27
15KPA22A	22.0	24.4	10	500	37.1	404.0	24
P 15KPA24	24.0	26.7	5	150	45.0	333.0	30
P 15KPA24A	24.0	26.7	5	150	40.7	369.0	27
P 15KPA26	26.0	28.9	5	50	48.7	308.0	32
P 15KPA26A	26.0	28.9	5	50	44.0	341.0	29
P 15KPA28	28.0	31.1	5	25	52.4	286.0	35
P 15KPA28A	28.0	31.1	5	25	47.5	316.0	31
15KPA30	30.0	33.3	5	15	56.2	267.0	37
15KPA30A	30.0	33.3	5	15	50.7	296.0	34
15KPA33	33.0	36.7	5	10	60.6	248.0	42
15KPA33A	33.0	36.7	5	10	54.8	274.0	38
P 15KPA36	36.0	40.0	5	10	66.0	227.0	46
P 15KPA36A	36.0	40.0	5	10	59.7	251.0	41
15KPA40	40.0	44.4	5	10	72.8	206.0	51
15KPA40A	40.0	44.4	5	10	65.8	228.0	46
15KPA43	43.0	47.8	5	10	77.1	195.0	55
15KPA43A	43.0	47.8	5	10	69.7	215.0	50
15KPA45	45.0	50.0	5	10	80.7	186.0	57
15KPA45A	45.0	50.0	5	10	73.0	205.0	52
15KPA48	48.0	53.3	5	10	85.9	175.0	62
15KPA48A	48.0	53.3	5	10	77.7	193.0	56
15KPA51	51.0	56.7	5	10	91.5	164.0	66
15KPA51A	51.0	56.7	5	10	82.8	181.0	60
15KPA54	54.0	60.0	5	10	96.8	155.0	70
15KPA54A	54.0	60.0	5	10	87.5	171.0	63
P 15KPA58	58.0	64.4	5	10	104.0	144.0	76
P 15KPA58A	58.0	64.4	5	10	94.0	160.0	68
15KPA60	60.0	66.7	5	10	107.0	140.0	78
15KPA60A	60.0	66.7	5	10	97.3	154.0	71
15KPA64	64.0	71.1	5	10	115.0	130.0	84
15KPA64A	64.0	71.1	5	10	104.0	144.0	76
15KPA70	70.0	77.8	5	10	126.0	119.0	92
15KPA70A	70.0	77.8	5	10	114.0	132.0	83
15KPA75	75.0	83.3	5	10	135.0	111.0	100
15KPA75A	75.0	83.3	5	10	122.0	123.0	89
15KPA78	78.0	86.7	5	10	140.0	107.0	104
15KPA78A	78.0	86.7	5	10	126.0	119.0	93
15KPA85	85.0	94.4	5	10	152.0	99.0	113
15KPA85A	85.0	94.4	5	10	137.0	109.0	102
P 15KPA90	90.0	100.0	5	10	160.0	94.0	120
P 15KPA90A	90.0	100.0	5	10	146.0	103.0	109
15KPA100	100.0	111.0	5	10	179.0	84.0	134
15KPA100A	100.0	111.0	5	10	162.0	93.0	121
15KPA110	110.0	122.0	5	10	196.0	77.0	147
15KPA110A	110.0	122.0	5	10	178.0	84.0	133
15KPA120	120.0	133.0	5	10	214.0	70.0	161
15KPA120A	120.0	133.0	5	10	193.0	78.0	145
P 15KPA130	130.0	144.0	5	10	231.0	65.0	174
P 15KPA130A	130.0	144.0	5	10	209.0	72.0	157
15KPA150	150.0	167.0	5	10	268.0	56.0	202
15KPA150A	150.0	167.0	5	10	243.0	62.0	183
P 15KPA160	160.0	178.0	5	10	287.0	52.0	216
P 15KPA160A	160.0	178.0	5	10	259.0	58.0	195
P 15KPA170	170.0	189.0	5	10	304.0	49.0	229
P 15KPA170A	170.0	189.0	5	10	275.0	55.0	207
15KPA180	180.0	200.0	5	10	321.0	47.0	242
15KPA180A	180.0	200.0	5	10	291.0	52.0	219
15KPA200	200.0	222.0	5	10	356.0	42.0	269
15KPA200A	200.0	222.0	5	10	322.0	47.0	243
15KPA220	220.0	245.0	5	10	393.0	38.0	297
15KPA220A	220.0	245.0	5	10	356.0	42.0	269
15KPA240	240.0	267.0	5	10	428.0	35.0	324
15KPA240A	240.0	267.0	5	10	388.0	39.0	293
15KPA260	260.0	289.0	5	10	464.0	32.0	352
15KPA260A	260.0	289.0	5	10	419.0	36.0	317
15KPA280	280.0	311.0	5	10	500.0	30.0	378
15KPA280A	280.0	311.0	5	10	452.0	33.0	342

TYPICAL RELAY DRIVE PROTECTION APPLICATION



15KPA SERIES PACKAGE DIMENSIONS



NOTES

Note 1: P = Preferred part. For preferred parts and bidirectional devices, consult factory for minimum order quantity and delivery. Part numbers shown are unidirectional devices. Add "C" or "CA" suffix to specify bidirectional devices, such as 15KPA17C or 15KPA17CA.

Note 2: $V_F = 7.5V @ 200A, 8.3 ms - 1/2$ sine wave (Unidirectional).

THYRISTOR SURGE SUPPRESSOR

APPLICATIONS

- T1/E1 Trunk & Line Card
- SLIC Line Card
- DBX Branch Exchange Switches
- FCC Part 68 Customer Premise Equipment
- Line Interface Modem
- ADSL Architecture Interface
- ISDN Architecture Interface

FEATURES

- Meets IEC 1000-4-4 & -5 Industry Requirements
- Provides Protection in Accordance with FCC Part 68, UL 1459, Bellcore 1089, ITU-TK.20 & K.21
- Peak Off-State Voltage from 58 to 300 Volts
- Surge Current Capability (See Surge Ratings Table)
- ESD Protection > 40 kilovolts
- Low Capacitance for T1/E1 Trunk & Line Card Applications
- UL 94V-0 Flammability Classification

MAXIMUM RATINGS

- Surge Current: 60A Max. (50/60 Hz) (I_{TSM})
- Storage Temperatures: -55° to + 150°C
- Junction Temperatures: T_j = -40° to 150°C
- Thermal Resistance for PPxxxxSA in a DO-214AA Package is $R_{\theta JC}$ = 28°C/Watt & $R_{\theta JA}$ = 90°C/Watt
- Thermal Resistance for PPxxxxSB or SC in a DO-214AA Package is $R_{\theta JC}$ = 26°C/Watt & $R_{\theta JA}$ = 85°C/Watt
- Critical Rate of Rise of Maximum On-State Current: di/dt = 500A/ μ s
- Critical Rate of Rise of Maximum Off-State Voltage: dv/dt > 2kv/ μ s

MECHANICAL CHARACTERISTICS

- Package: Molded DO-214AA (JEDEC)
- Approximate Weight: 2.5 grams
- Body Marked with Logo and Marking Code

SURGE RATINGS						
SERIES	I_{pp} 2 X 10 μ s AMPS	I_{pp} 10 X 160 μ s AMPS	I_{pp} 10 X 560 μ s AMPS	I_{pp} 10 X 1000 μ s AMPS	I_{TSM} 60 Hz AMPS	di/dt AMPS/ μ s
SA	N/A	100	50	N/A	20	500
SB	N/A	150	100	N/A	30	500
SC	500	200	N/A	100	60	500

IEC 1000-4 COMPATIBLE



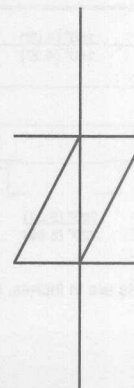
DO-214AA PACKAGE

DESCRIPTION

The PPxxxxSA, SB and SC families are a series of Thyristor surge suppression (TSS) devices designed to protect telecommunication equipment against lightning and transients induced by AC power lines. These devices can be used on central office equipment, PBX, DSU, OCU, digital telephones, fax machines, modems and radio controlled equipment. The bidirectional configuration provides protection for both positive and negative transients and the discrete surface mount package allows individual placement of the device on line cards or other locations where multiple component devices do not offer the versatile in board trace layout.

The ProTek TSS device can be used to provide protection in accordance with industry standard requirements, such as FCC Part 68, ANSI C62.41, UL 1459 and GR-1089-CORE. Their low capacitance is ideal for T1/E1 trunk or line card applications.

DEVICE SYMBOL

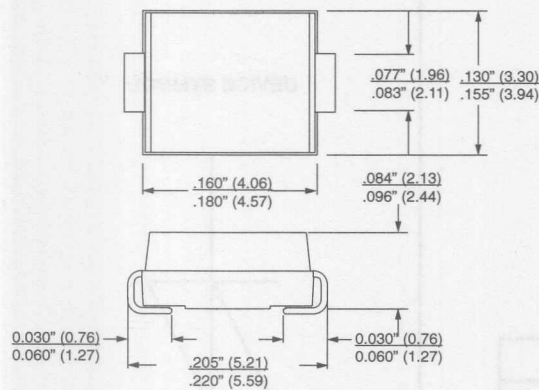


ELECTRICAL CHARACTERISTICS @ 25°C Ambient Temperature

PROTEK PART NUMBER	DEVICE MARKING CODE	REPETITIVE PEAK OFF-STATE VOLTAGE V_{DRM} VOLTS	SWITCHING VOLTAGE @ 100V/ μ s V_s VOLTS	MINIMUM HOLDING CURRENT (Figure 4) di/dt = 1A/ms I_H mA	SWITCHING CURRENT I_s mA	MAXIMUM OFF-STATE CURRENT (Figure 2) @ V_{DRM} I_{DRM} μ A	MAXIMUM ON-STATE VOLTAGE (Figure 3) @ I_T V_T VOLTS	ON-STATE CURRENT I_T A	TYPICAL CAPACITANCE (See Note 1) @ 2V, 1 MHZ C pF
PP0640SA	GC	58	77	150	800	5	5	1.0	60
PP0720SA	GD	65	88	150	800	5	5	1.0	60
PP0800SA	GE	75	98	150	800	5	5	1.0	60
PP1100SA	GF	90	130	150	800	5	5	1.0	60
PP1300SA	GG	120	160	150	800	5	5	1.0	40
PP1500SA	GH	140	180	150	800	5	5	1.0	40
PP1800SA	GI	160	220	150	800	5	5	1.0	40
PP2300SA	GJ	190	260	150	800	5	5	1.0	30
PP2600SA	GK	220	300	150	800	5	5	1.0	30
PP3100SA	GL	275	350	150	800	5	5	1.0	30
PP3500SA	GM	300	400	150	800	5	5	1.0	30
PP0640SB	GP	58	77	150	800	5	5	1.0	60
PP0720SB	GQ	65	88	150	800	5	5	1.0	60
PP0800SB	GR	75	98	150	800	5	5	1.0	60
PP1100SB	GS	90	130	150	800	5	5	1.0	60
PP1300SB	GT	120	160	150	800	5	5	1.0	40
PP1500SB	GU	140	180	150	800	5	5	1.0	40
PP1800SB	GV	160	220	150	800	5	5	1.0	40
PP2300SB	GW	190	260	150	800	5	5	1.0	30
PP2600SB	GX	220	300	150	800	5	5	1.0	30
PP3100SB	GY	275	350	150	800	5	5	1.0	30
PP3500SB	GZ	300	400	150	800	5	5	1.0	30
PP0640SC	HC	58	77	150	800	5	5	1.0	120
PP0720SC	HD	65	88	150	800	5	5	1.0	120
PP0800SC	HE	75	98	150	800	5	5	1.0	120
PP1100SC	HF	90	130	150	800	5	5	1.0	120
PP1300SC	HG	120	160	150	800	5	5	1.0	80
PP1500SC	HH	140	180	150	800	5	5	1.0	80
PP1800SC	HI	160	220	150	800	5	5	1.0	80
PP2300SC	HJ	190	260	150	800	5	5	1.0	60
PP2600SC	HK	220	300	150	800	5	5	1.0	60
PP3100SC	HL	275	350	150	800	5	5	1.0	60
PP3500SC	HM	300	400	150	800	5	5	1.0	60

Note 1: Capacitance imbalance between positive and negative polarities is typically < 15pF.

DO-214AA PACKAGE DIMENSIONS



Measurements are in inches, (mm) denotes millimeters

FIGURE 1 PULSE WAVE FORM EXAMPLE

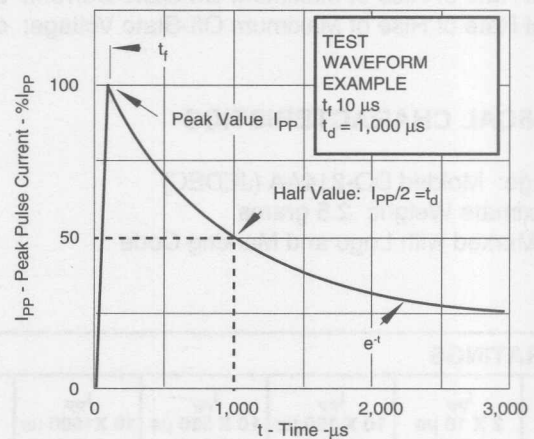


FIGURE 2
TYPICAL PEAK OFF-STATE CURRENT VS JUNCTION TEMPERATURE

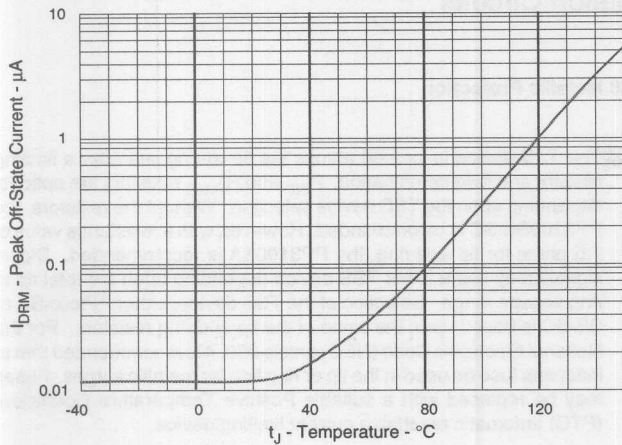


FIGURE 3
TYPICAL ON-STATE CURRENT VS ON-STATE VOLTAGE

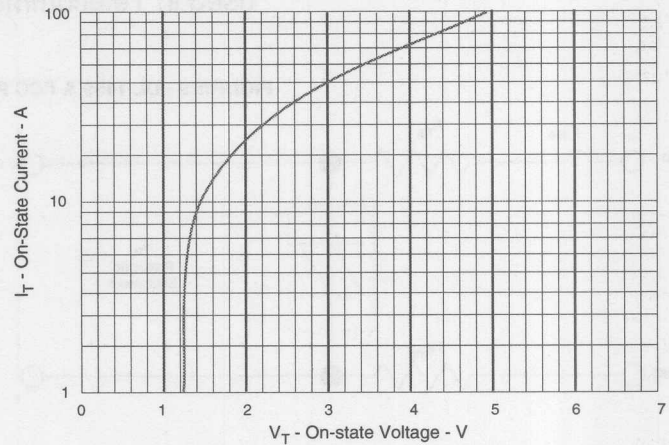


FIGURE 4
TYPICAL HOLDING CURRENT VS JUNCTION TEMPERATURE

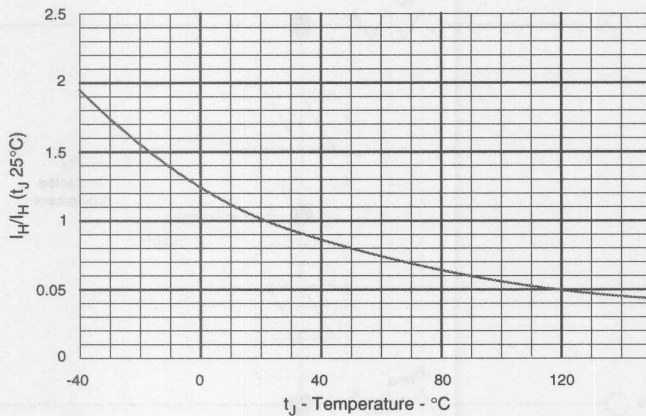


FIGURE 5
TYPICAL NORMALIZED V_S VS JUNCTION TEMPERATURE

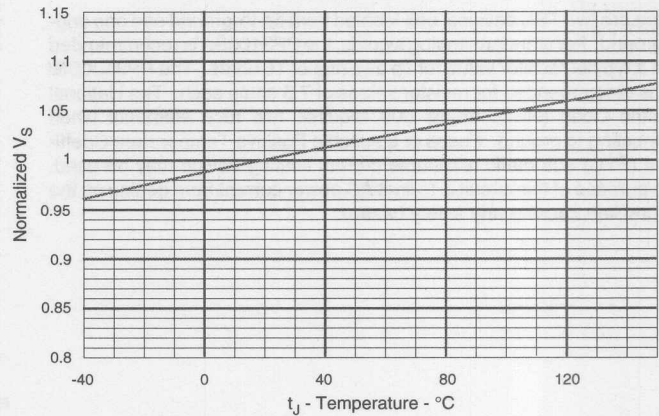


FIGURE 6
ON-STATE CURRENT VS SURGE CURRENT DURATION

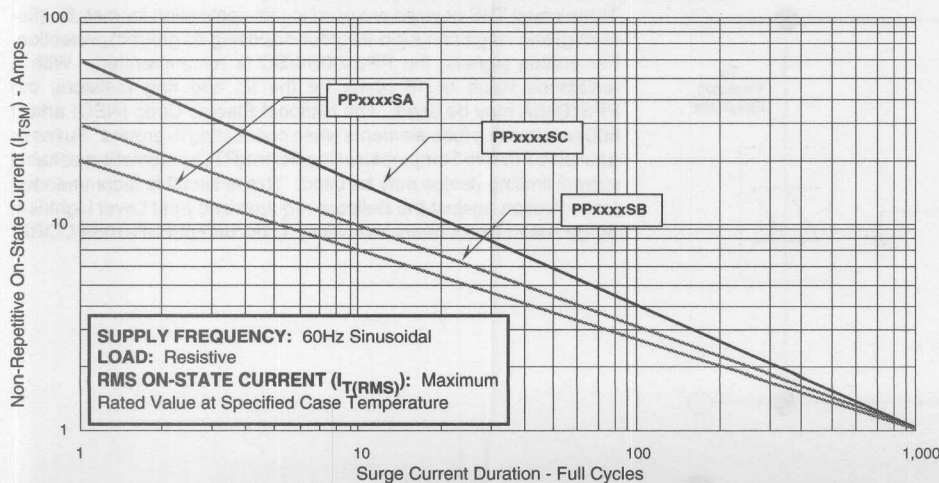
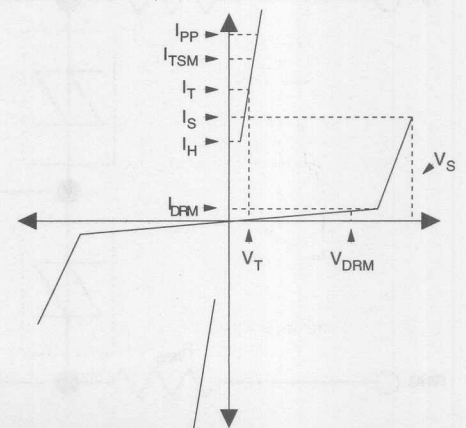
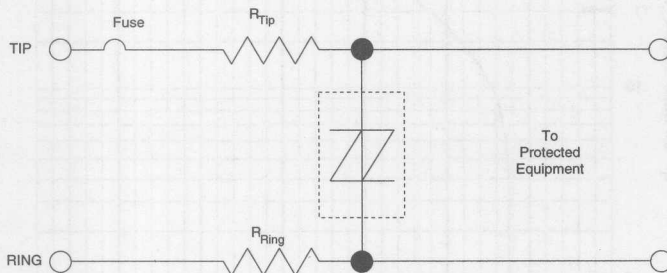


FIGURE 7
V-I CHARACTERISTICS CURVE



Application Notes for Thyristor Surge Suppressors used in Telecommunication Circuits

FIGURE 8 - UL 1459 & FCC Part 68 Metallic Protection



The TSS device is located across the tip-to-ring line after a limiting resistor and fuse combination. R_{TIP} and R_{RING} resistors are optional depending upon the TSS device selection. Without the resistors, the PP3100SB/SC is recommended. However, with a resistance value of 7.5 ohms for tip and ring, the PP3100SA is recommended. Digital signals may use a lower TSS device depending upon the total tip to ring voltage range. Selection of the TSS device, either PPxxxxSA or SB/SC is based upon the value of the tip and ring resistors. For the National Electronic Code (NEC) article 800, it is recommended that at least one fuse be used in the tip or ring line for metallic surges. Fuses may be replaced with a suitable Positive Temperature Coefficient (PTC) automatic resettable current limiting device.

FIGURE 9 - UL 1459 & FCC Part 68 - Longitudinal Protection

There are two TSS devices, one located from tip-to-ground and one ring-to-ground. For standard analog signals, the PP3100SA is recommended with a typical resistor value for tip and ring of 15 ohms. The PP3100SB/SC is recommended for resistor values of 7.5 ohms each. The National Electric Code (NEC) article 800 requires two fuse elements when connecting to ground. Fuses or a suitable Positive Temperature Coefficient (PTC) automatic resettable current limiting device may be used. The purpose of this circuit is to limit AC power current from getting on the ground line causing any safety hazard.

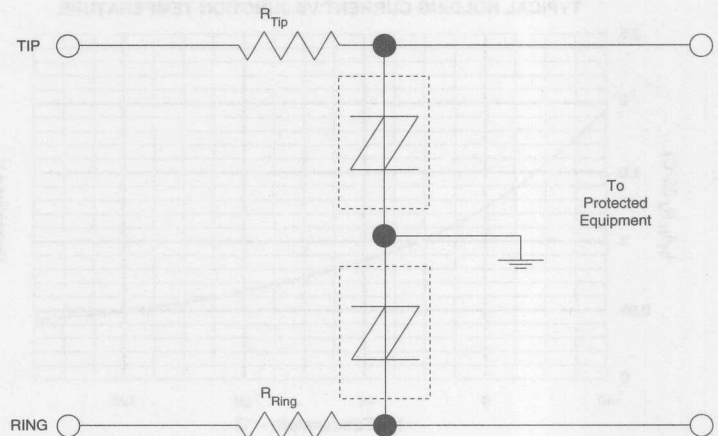
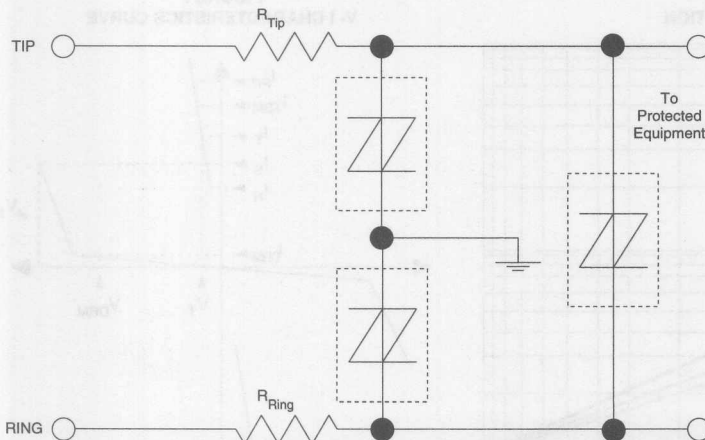


FIGURE 10 - UL 1459 & FCC Part 68 - Metallic and Longitudinal Protection



Three equal TSS devices are used in this application for metallic (tip-to-ring) and longitudinal (tip-to-ground and ring-to-ground) protection. For analog signals, the PP3100SB/SC is recommended. With a resistance value of 15 ohms for the tip and ring resistors, the PP3100SA may be used. The National Electric Code (NEC) article 800 requires two fuse elements when connecting to ground. Fuses or a suitable Positive Temperature Coefficient (PTC) automatic resettable current limiting device may be used. This circuit is recommended for protection against the Bellcore requirement: First Level Lightning Surge Tests (Telecommunications Port), document # GR-1089-CORE.

HIGH CURRENT DISCRETE TVS

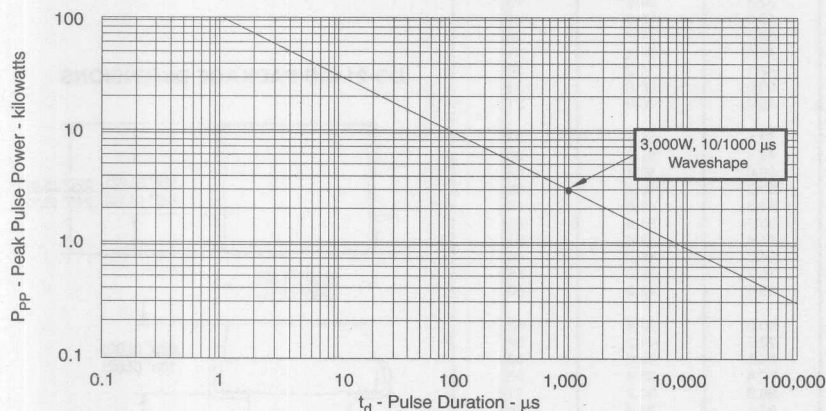
APPLICATIONS

- General Power Bus Protection
- UPS Power Switches
- DC Board Level Protection
- Industrial & Commercial Power Circuits

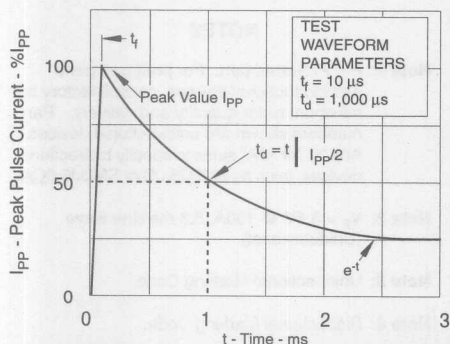
FEATURES

- 3,000 Watts Peak Pulse Power Dissipation (10/1000 μ s)
- Available in Numerous Voltage Types Ranging from 5.0V to 170V
- Unidirectional & Bidirectional Device Types
- Low Inductance
- UL 94V-0 Flammability Classification

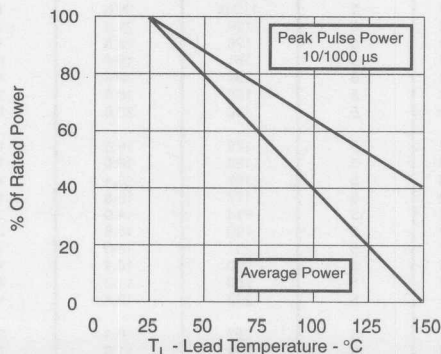
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



3,000 WATTS



DO-214AB PACKAGE

MAXIMUM RATINGS

- 3,000 Watts Peak Pulse Dissipation @25°C (See Figure 1)
- Operating & Storage Temperature: -55°C to 150°C
- Forward Surge Rating: 200A, 1/20 seconds @25°C, Unidirectional Only
- Steady State Power Dissipation: 5.0W $T_L = 75^\circ\text{C}$
- Repetition Rate (Duty Cycle): 0.01%
- t_{Clamping} (0 Volts to V_{BR} min):
Unidirectional < 1×10^{-12} seconds
Bidirectional < 10×10^{-9} seconds

MECHANICAL CHARACTERISTICS

- Package: Molded Surface Mount
- Packaging: 16mm Tape per EIA Std.
- Approximate Weight: 4 grams
- Positive Terminal Marked with Polarity Band (except Bidirectional) or notch (Top Surface)
- Body Marked with Logo & Type Code

DESCRIPTION

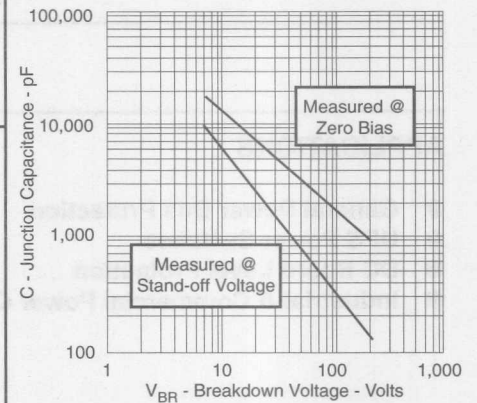
The SMDJ family is a series of transient voltage suppressors (TVS) designed for use in applications where large voltage transients can permanently damage sensitive components.

The SMDJ series has a peak pulse power rating of 3,000 Watts for an 10/1000 μ s waveshape. This series is available in voltages ranging from 5.0 Volts to 170 Volts.

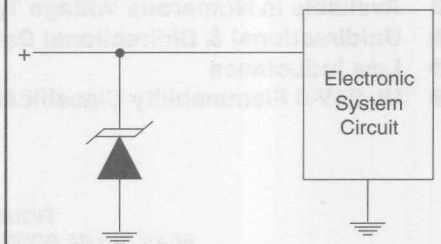
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1 & Note 2)	DEVICE MARKING CODE		RATED STAND-OFF VOLTAGE	BREAKDOWN VOLTAGE		MAXIMUM LEAKAGE CURRENT (See Note 5) @ V _{WM} I _D μA	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ I _p = 1 A V _C VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ I _{PP} AMPS	MAXIMUM TEMPERATURE COEFFICIENT OF V _(BR) θV _(BR) mV/°C
	See Note 3	See Note 4		MIN V _(BR) VOLTS	@ I _T mA				
P SMDJ5.0	RDD	DDD	5.0	6.40	10	1000	9.6	312.5	5.0
P SMDJ5.0A	RDE	DDE	5.0	6.40	10	1000	9.2	326.0	5.0
P SMDJ6.0	RDF	DDF	6.0	6.67	10	1000	11.4	263.2	5.0
P SMDJ6.0A	RDG	DDG	6.0	6.67	10	1000	10.3	291.3	5.0
SMDJ6.5	RDH	DDH	6.5	7.22	10	500	12.3	243.9	5.0
SMDJ6.5A	RDK	DDK	6.5	7.22	10	500	11.2	267.9	5.0
SMDJ7.0	PDL	DDL	7.0	7.78	10	200	13.3	225.6	6.0
SMDJ7.0A	PDM	DDM	7.0	7.78	10	200	12.0	250.0	6.0
SMDJ7.5	PDN	DDN	7.5	8.33	1	100	14.3	209.8	7.0
SMDJ7.5A	PDP	DDP	7.5	8.33	1	100	12.9	232.6	7.0
P SMDJ8.0	PDQ	DDQ	8.0	8.89	1	50	15.0	200.0	7.0
P SMDJ8.0A	PDR	DDR	8.0	8.89	1	50	13.6	220.6	7.0
SMDJ8.5	PDS	DDS	8.5	9.44	1	25	15.9	188.6	8.0
SMDJ8.5A	PDT	DDT	8.5	9.44	1	25	14.4	208.4	8.0
SMDJ9.0	PDU	DDU	9.0	10.0	1	10	16.9	177.4	9.0
SMDJ9.0A	PDV	DDV	9.0	10.0	1	10	15.4	194.8	9.0
P SMDJ10	PDW	DDW	10	11.1	1	5	18.8	159.6	10
P SMDJ10A	PDX	DDX	10	11.1	1	5	17.0	176.4	10
SMDJ11	PDY	DDY	11	12.2	1	5	20.1	149.2	11
SMDJ11A	PDZ	DDZ	11	12.2	1	5	18.2	164.8	11
P SMDJ12	PED	DED	12	13.3	1	5	22.0	136.4	12
P SMDJ12A	PEE	DEE	12	13.3	1	5	19.9	150.6	12
SMDJ13	PEF	DEF	13	14.4	1	5	23.8	126.0	13
SMDJ13A	PEG	DEG	13	14.4	1	5	21.5	139.4	13
SMDJ14	PEH	DEH	14	15.6	1	5	25.8	116.2	14
SMDJ14A	PEK	DEK	14	15.6	1	5	23.2	129.4	14
P SMDJ15	PEL	DEL	15	16.7	1	5	26.9	111.6	16
P SMDJ15A	PEM	DEM	15	16.7	1	5	24.4	123.0	16
SMDJ16	PEN	DEN	16	17.8	1	5	28.8	104.2	19
SMDJ16A	PEP	DEP	16	17.8	1	5	26.0	115.4	17
SMDJ18	PES	DES	18	20.0	1	5	32.2	93.2	21
SMDJ18A	PET	DET	18	20.0	1	5	29.9	102.8	20
P SMDJ20	PEU	DEU	20	22.2	1	5	35.8	83.8	25
P SMDJ20A	PEV	DEV	20	22.2	1	5	32.4	92.6	23
P SMDJ24	PEY	DEY	24	26.7	1	5	43.0	69.8	31
P SMDJ24A	PEZ	DEZ	24	26.7	1	5	38.9	77.2	28
P SMDJ26	PFD	DFD	26	28.9	1	5	46.6	64.4	31
P SMDJ26A	PFE	DFE	26	28.9	1	5	42.1	71.2	30
P SMDJ28	PFF	DFD	28	31.1	1	5	50.0	60.0	35
P SMDJ28A	PFG	DFG	28	31.1	1	5	45.4	66.0	31
SMDJ30	PFH	DFH	30	33.3	1	5	53.5	56.0	39
SMDJ30A	PFK	DFK	30	33.3	1	5	48.4	62.0	36
SMDJ33	PFL	DFL	33	36.7	1	5	59.0	50.4	42
SMDJ33A	PFM	DFM	33	36.7	1	5	53.3	56.2	39
P SMDJ36	PFN	DFN	36	40.0	1	5	64.3	46.6	46
P SMDJ36A	PFP	DFP	36	40.0	1	5	58.1	51.6	41
SMDJ40	PFQ	DFQ	40	44.4	1	5	71.4	42.0	51
SMDJ40A	PFR	DFR	40	44.4	1	5	64.5	46.4	46
SMDJ43	PFS	DFS	43	47.8	1	5	76.7	39.2	55
SMDJ43A	PFT	DFT	43	47.8	1	5	69.4	43.2	50
SMDJ45	PFU	DFU	45	50.0	1	5	80.3	37.4	58
SMDJ45A	PFV	DFV	45	50.0	1	5	72.7	41.2	52
SMDJ48	PFW	DFW	48	53.3	1	5	85.5	35.0	63
SMDJ48A	PFX	DFX	48	53.3	1	5	77.4	38.8	56
SMDJ54	RGC	DGD	54	60.0	1	5	96.3	31.2	71
SMDJ54A	RGE	DGE	54	60.0	1	5	87.1	34.4	65
P SMDJ58	PGF	DGF	58	64.4	1	5	103.0	29.2	78
P SMDJ58A	PGG	DGG	58	64.4	1	5	93.6	32.0	70
SMDJ60	PGH	DGH	60	66.7	1	5	107.0	28.0	80
SMDJ60A	PGK	DGK	60	66.7	1	5	96.8	31.0	71
SMDJ64	PGL	DGL	64	71.1	1	5	114.0	26.4	86
SMDJ64A	PGM	DGM	64	71.1	1	5	103.0	29.2	76
SMDJ70	PGN	DGN	70	77.8	1	5	125.0	24.0	94
SMDJ70A	PGP	DGP	70	77.8	1	5	113.0	26.6	85
SMDJ78	PGS	DGS	78	86.7	1	5	139	21.6	105
SMDJ78A	PGT	DGT	78	86.7	1	5	126	22.8	95
SMDJ85	PGU	DGU	85	94.4	1	5	151	19.8	114
SMDJ85A	PGV	DGV	85	94.4	1	5	137	20.8	103
P SMDJ90	PGW	DGW	90	100	1	5	160	18.8	121
P SMDJ90A	PGX	DGX	90	100	1	5	146	20.6	110
SMDJ100	PGY	DGY	100	111	1	5	179	16.8	135
SMDJ100A	PGZ	DGZ	100	111	1	5	162	18.6	123
SMDJ110	PHD	DHD	110	122	1	5	196	15.4	148
SMDJ110A	PHE	DHE	110	122	1	5	177	16.8	133
SMDJ120	PHF	DHF	120	133	1	5	214	14.0	162
SMDJ120A	PHG	DHG	120	133	1	5	193	15.6	146
P SMDJ130	PHH	DHH	130	144	1	5	231	13.0	175
P SMDJ130A	PHK	DHK	130	144	1	5	209	14.4	158
SMDJ150	PHL	DHL	150	167	1	5	268	11.2	203
SMDJ150A	PHM	DHM	150	167	1	5	243	12.4	184
P SMDJ160	PHN	DHN	160	178	1	5	287	10.4	217
P SMDJ160A	PHP	DHP	160	178	1	5	259	11.6	196
P SMDJ170	PHQ	DHQ	170	189	1	5	304	9.8	230
P SMDJ170A	PHR	DHR	170	189	1	5	275	11.0	208

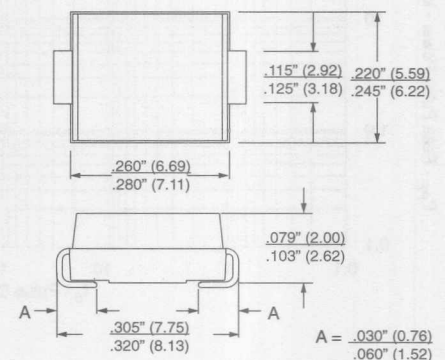
**FIGURE 4
TYPICAL CAPACITANCE Vs
BREAKDOWN VOLTAGE
(Unidirectional Only)**



DC POWER SUPPLY APPLICATION



DO-214AB PACKAGE DIMENSIONS



Measurements are in inches, (mm) denotes millimeters

NOTES

Note 1: P = Preferred part. For preferred parts and bidirectional devices, consult factory for minimum order quantity and delivery. Part numbers shown are unidirectional devices. Add "C" or "CA" suffix to specify bidirectional devices, such as SMDJ5.0C or SMDJ5.0CA.

Note 2: V_F = 3.5V @ 100A, 8.3 ms sine wave (Unidirectional)

Note 3: Unidirectional Marking Code.

Note 4: Bidirectional Marking Code.

Note 5: For bidirectional types 10 Volts and under, the I_D limits is doubled.

SECTION 5

Power Transient Voltage Suppressor Assemblies

<u>Contents</u>		<u>Page</u>
15KP Series:	15 kW Molded High Current Voltage Suppressor Assembly - Industrial	5-3
60KS & 90KS:	60 & 90 KW Hermetic AC Power Voltage Suppressor Assembly - Aerospace	5-5
704-15K Series:	15 kW Hermetic High Power Voltage Suppressor Assembly - Aerospace	5-7
GPZ Series:	10 & 30 kW Hermetic High Power Voltage Suppressor Assembly	5-9
PHP & PIP Series:	7.5 & 15 kW Hermetic & Molded AC Power Voltage Suppressor Assembly	5-11

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Power Transient Voltage Suppressor Assemblies

SECTION 15

Contents

Contents

15-1	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace	15-1	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace
15-2	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace	15-2	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace
15-3	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace	15-3	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace
15-4	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace	15-4	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace
15-5	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace	15-5	15 kW Metal High Constant Voltage Suppressor Assembly - Airspace

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HIGH CURRENT VOLTAGE SUPPRESSOR

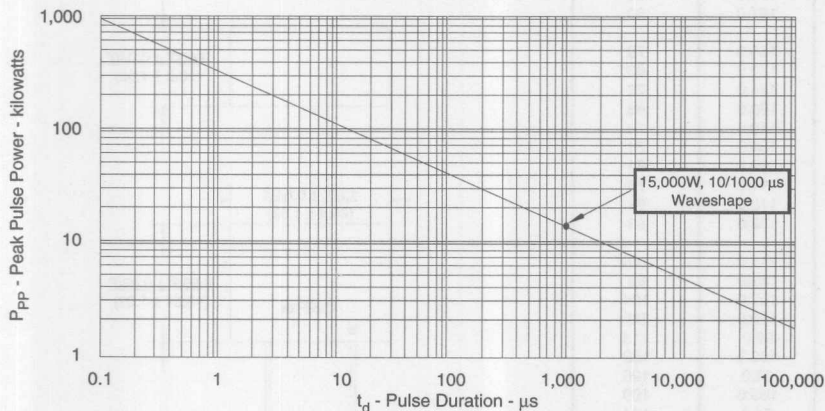
APPLICATIONS

- Relay Drives
- Motor (Start/Stop) Back EMF Protection
- Module Lightning Protection

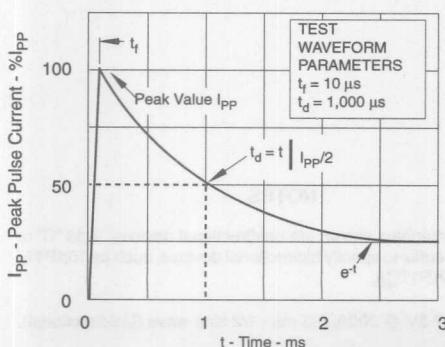
FEATURES

- 15,000 Watts Peak Pulse Power Dissipation (10/1000 μ s)
- Available in Voltage Types Ranging from 17.0V to 280V
- Easy Mounting to Printed Circuit Boards
- UL 94V-0 Flammability Classification

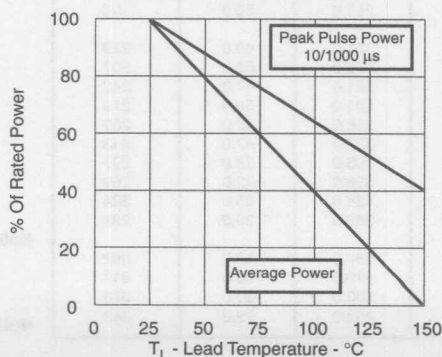
**FIGURE 1
PEAK PULSE POWER VS PULSE TIME**



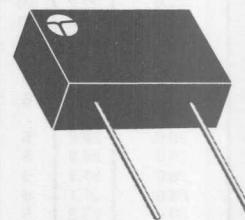
**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



15,000 WATTS



SINGLE ENDED

MAXIMUM RATINGS

- 15,000 Watts Peak Pulse Dissipation @25°C (See Figure 1)
- Operating & Storage Temperatures: -55°C to +150°C
- Forward Surge Rating: 100A, 1/20 seconds @25°C
- Steady State Power Dissipation: 7.0W $T_A = 25^\circ\text{C}$
- Repetition Rate (Duty Cycle): 0.05%
- t_{Clamping} (0 Volts to V_{BR} min):
Unidirectional $< 1 \times 10^{-12}$ seconds
Bidirectional $< 10 \times 10^{-9}$ seconds

MECHANICAL CHARACTERISTICS

- Package: Molded Case
- Approximate Weight: 13 grams
- Positive Terminal Marked with Dot
- Body Marked with Logo & Part No.

DESCRIPTION

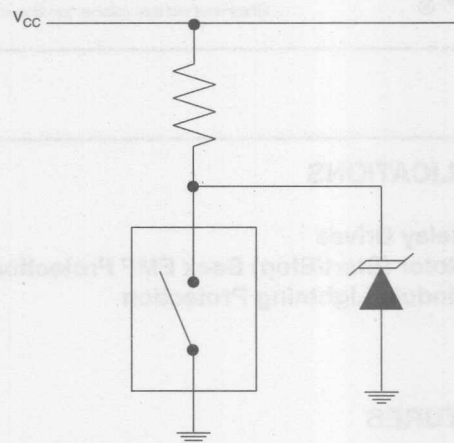
The 15KP family is a series of discrete 15,000 Watt, silicon transient voltage suppressor diodes designed for use in applications where large voltage transients can permanently damage voltage sensitive components and equipment.

The 15KP series has a peak pulse power (P_{PP}) rating of 15,000 Watts for an 10/1000 μ s waveshape. This series is available in voltages ranging from 17.0 Volts to 280 Volts with 5 percent and 10 percent tolerances. Both tolerances are referenced to the power supply output or operating voltage level.

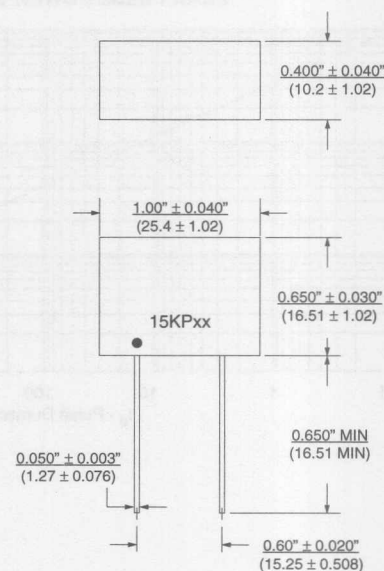
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1 & Note 2)	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	BREAKDOWN VOLTAGE		MAXIMUM LEAKAGE CURRENT I_D μA	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) V_C VOLTS	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) I_{PP} AMPS	MAXIMUM TEMPERATURE COEFFICIENT OF $V_{(BR)}$ $\Theta V_{(BR)}$ mV/°C
		MIN $V_{(BR)}$ VOLTS	@ I_T mA				
15KP17	17.0	18.9	50	5000	32.3	464.0	19
15KP17A	17.0	18.9	50	5000	29.3	512.0	17
15KP18	18.0	20.0	50	5000	34.2	439.0	20
15KP18A	18.0	20.0	50	5000	30.9	485.0	18
15KP20	20.0	22.2	20	1500	37.9	396.0	24
15KP20A	20.0	22.2	20	1500	34.3	437.0	21
15KP22	22.0	24.4	10	500	41.1	365.0	27
15KP22A	22.0	24.4	10	500	37.1	404.0	24
15KP24	24.0	26.7	5	150	45.0	333.0	30
15KP24A	24.0	26.7	5	150	40.7	369.0	27
15KP26	26.0	28.9	5	50	48.7	308.0	32
15KP26A	26.0	28.9	5	50	44.0	341.0	29
15KP28	28.0	31.1	5	25	52.4	286.0	35
15KP28A	28.0	31.1	5	25	47.5	316.0	31
15KP30	30.0	33.3	5	15	56.2	267.0	27
15KP30A	30.0	33.3	5	15	50.7	296.0	34
15KP33	33.0	36.7	5	10	60.6	248.0	42
15KP33A	33.0	36.7	5	10	54.8	274.0	38
15KP36	36.0	40.0	5	10	66.0	227.0	46
15KP36A	36.0	40.0	5	10	59.7	251.0	41
15KP40	40.0	44.4	5	10	72.8	206.0	51
15KP40A	40.0	44.4	5	10	65.8	228.0	46
15KP43	43.0	47.8	5	10	77.1	195.0	55
15KP43A	43.0	47.8	5	10	69.7	215.0	50
15KP45	45.0	50.0	5	10	80.7	186.0	57
15KP45A	45.0	50.0	5	10	73.0	205.0	52
15KP48	48.0	53.3	5	10	85.9	175.0	62
15KP48A	48.0	53.3	5	10	77.7	193.0	56
15KP51	51.0	56.7	5	10	91.5	164.0	66
15KP51A	51.0	56.7	5	10	82.8	181.0	60
15KP54	54.0	60.0	5	10	96.8	155.0	70
15KP54A	54.0	60.0	5	10	87.5	171.0	63
15KP58	58.0	64.4	5	10	104.0	144.0	76
15KP58A	58.0	64.4	5	10	94.0	160.0	68
15KP60	60.0	66.7	5	10	107.0	140.0	78
15KP60A	60.0	66.7	5	10	97.3	154.0	71
15KP64	64.0	71.1	5	10	115.0	130.0	84
15KP64A	64.0	71.1	5	10	104.0	144.0	76
15KP70	70.0	77.8	5	10	126.0	119.0	92
15KP70A	70.0	77.8	5	10	114.0	132.0	83
15KP75	75.0	83.3	5	10	135.0	111.0	100
15KP75A	75.0	83.3	5	10	122.0	123.0	89
15KP78	78.0	86.7	5	10	140.0	107.0	104
15KP78A	78.0	86.7	5	10	126.0	119.0	93
15KP85	85.0	94.4	5	10	152.0	99.0	113
15KP85A	85.0	94.4	5	10	137.0	109.0	102
15KP90	90.0	100.0	5	10	160.0	94.0	120
15KP90A	90.0	100.0	5	10	146.0	103.0	109
15KP100	100.0	111.0	5	10	179.0	84.0	134
15KP100A	100.0	111.0	5	10	162.0	93.0	121
15KP110	110.0	122.0	5	10	196.0	77.0	147
15KP110A	110.0	122.0	5	10	178.0	84.0	133
15KP120	120.0	133.0	5	10	214.0	70.0	161
15KP120A	120.0	133.0	5	10	193.0	78.0	145
15KP130	130.0	144.0	5	10	231.0	65.0	174
15KP130A	130.0	144.0	5	10	209.0	72.0	157
15KP150	150.0	167.0	5	10	268.0	56.0	202
15KP150A	150.0	167.0	5	10	243.0	62.0	183
15KP160	160.0	178.0	5	10	287.0	52.0	216
15KP160A	160.0	178.0	5	10	259.0	58.0	195
15KP170	170.0	189.0	5	10	304.0	49.0	229
15KP170A	170.0	189.0	5	10	275.0	55.0	207
15KP180	180.0	200.0	5	10	321.0	47.0	242
15KP180A	180.0	200.0	5	10	291.0	52.0	219
15KP200	200.0	222.0	5	10	356.0	42.0	269
15KP200A	200.0	222.0	5	10	322.0	47.0	243
15KP220	220.0	245.0	5	10	393.0	38.0	297
15KP220A	220.0	245.0	5	10	356.0	42.0	269
15KP240	240.0	267.0	5	10	428.0	35.0	324
15KP240A	240.0	267.0	5	10	388.0	39.0	293
15KP260	260.0	289.0	5	10	464.0	32.0	352
15KP260A	260.0	289.0	5	10	419.0	36.0	317
15KP280	280.0	311.0	5	10	500.0	30.0	378
15KP280A	280.0	311.0	5	10	452.0	33.0	342

TYPICAL RELAY DRIVE PROTECTION APPLICATION



15KP SERIES PACKAGE DIMENSIONS



Measurements are in inches, (mm) denotes millimeters.

NOTES

Note 1: Part numbers shown are unidirectional devices. Add "C" or "CA" suffix to specify bidirectional devices, such as 15KP17C or 15KP17CA.

Note 2: $V_F = 7.5V$ @ 200A, 8.3 ms - 1/2 sine wave (Unidirectional).

SHIPBOARD/AC POWER BUS VOLTAGE SUPPRESSOR

APPLICATIONS

- AC Power Protection
- Shipboard (Line-Line) Protection
- Differential AC Power Bus
- Aircraft AC Power Bus

FEATURES

- 60,000 & 90,000 Watts Peak Pulse Power Dissipation (1.2/50 μ s)
- 200 Volts Bidirectional
- Military Processing Available per MIL-PRF-19500
- Exceeds DOD-STD-1399 & MIL-STD-704A Requirements
- Each Device 100% Tested
- Hermetically Sealed Sub-Assemblies
- UL 94V-0 Flammability Classification

DESCRIPTION

This series of devices were designed in accordance with DOD-STD-1399, section 300 (formally MIL-STD-1399) interface standard and MIL-STD-704A for shipboard systems, electrical power and alternating current. When large voltage transients endanger voltage sensitive components, the 60KS200C and 90KS200C has proven reliable for protection against power interruptions and shore power switch-over.

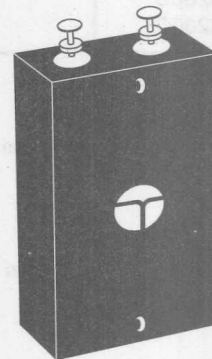
These silicon transient voltage suppressors (TVS) meet all applicable environmental requirements of MIL-STD-2036 (formally MIL-E-16400). The individual sub-modules can be selected for higher voltage applications as well as increased power capability. The 60KS and 90KS series can be screened upon request for military requirements in accordance with MIL-PRF-19500. Standard screening consists of 100% JANTX equivalent level testing per MIL-PRF-19500/507.

For ordering these options, use the following suffix:

- H1 - Submodule Screening
- H2 - Submodule and Module Screening
- H3 - Submodule and Module Screening
Module Group B & C Lot Testing

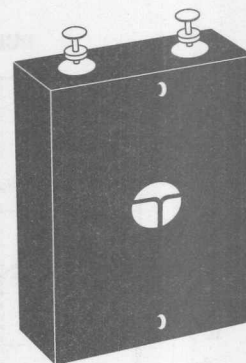
MAXIMUM RATINGS	
P_{PP} @ 25°C (See Figure 1)	60,000 & 90,000 Watts 1.2/50 μ s Waveshape
Steady State Power Dissipation	10.0 Watts T _A = 25°C
Operating & Storage Temperature	-65° to +150°C
t_{Clamping} (0 Volts to V_(BR) Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package	Molded Case, Glass-to-Metal Sub-Assemblies
Approximate Weight	50 grams
Device Markings	Logo, Date Code & Part Number
Miscellaneous	Sub-Assemblies Hermetically Sealed

60,000 WATTS



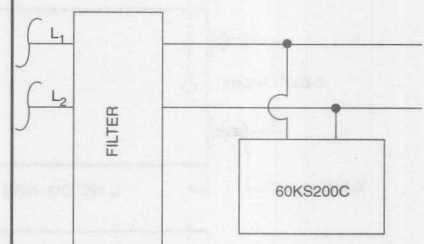
60KS200C

90,000 WATTS



90KS200C

AC POWER APPLICATION



Power TVS
Components

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ $I_{PPSM} = 180$ V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ I_{PP} AMPS
60KS200C	180	200	335	10	180
90KS200C	180	200	280	0.5	180

FIGURE 1
PEAK PULSE POWER VS. PULSE TIME

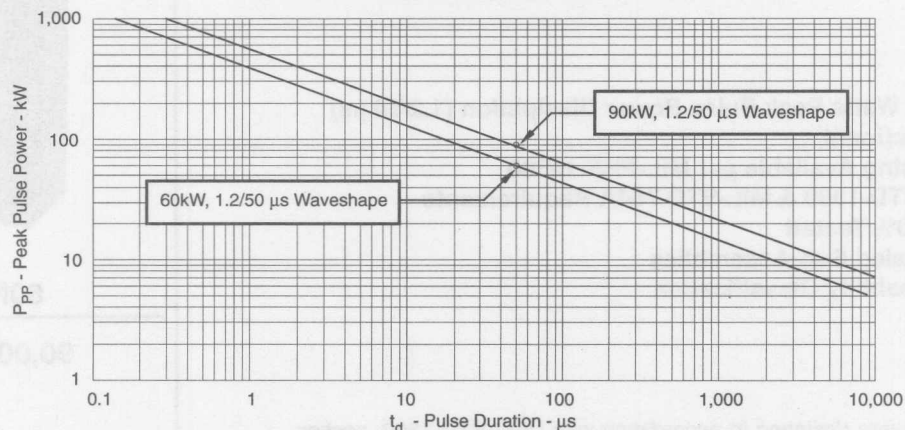


FIGURE 2
PULSE WAVE FORM

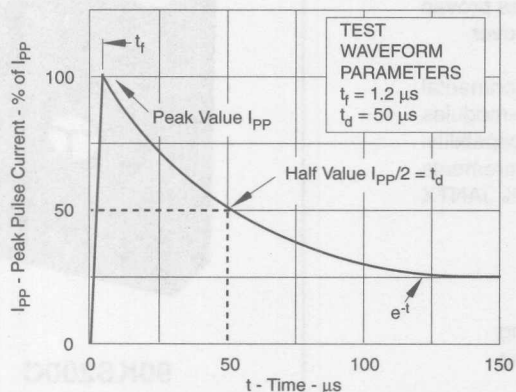
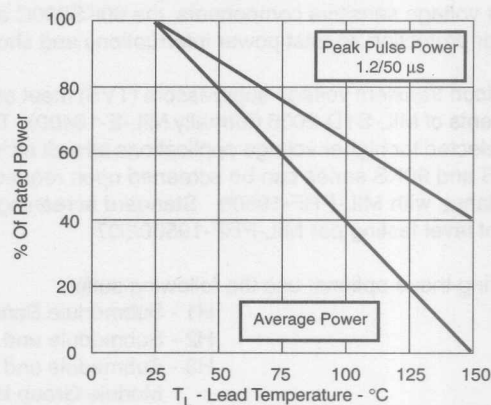
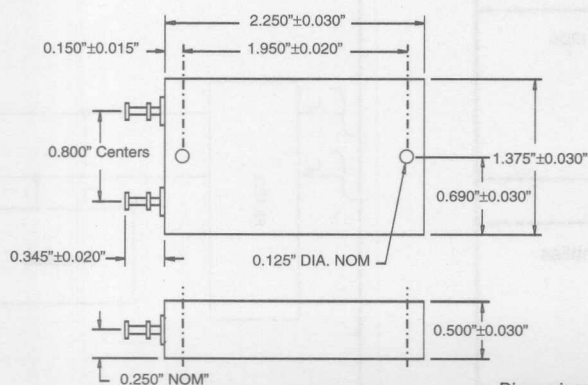


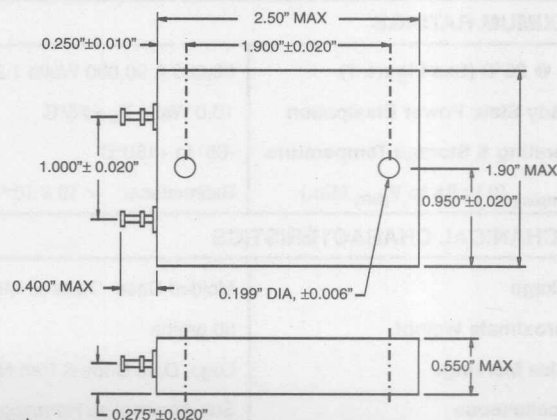
FIGURE 3
POWER DERATING CURVE



60KS DIMENSIONS



90KS DIMENSIONS



Dimensions shown in inches only.

HIGH POWER AIRCRAFT/VEHICLE DC BUS VOLTAGE SUPPRESSOR

APPLICATIONS

- DC Power Supply Protection
- MIL-STD-704 Power Bus Protection
- MIL-STD-1375 Power Bus Protection

FEATURES

- 15,000 Watts Peak Pulse Power Dissipation (10/1000 μ s)
- 28 Volt Power Supply Protection
- TX Screening Available
- Each Device 100% Tested
- UL 94V-0 Flammability Classification

DESCRIPTION

The 704-15K36 and 704-15K36T are 15 kilowatt silicon transient voltage suppressors (TVS) designed for use primarily in aircraft equipment in accordance with MIL-STD-704, MIL-STD-1375 and MIL-PRF-19500. These assemblies typically operate with a minimum source impedance of 0.25 ohms.

The 704-15K36 and 704-15K36T have a peak pulse current rating of 15,000 Watts for a 1 millisecond waveshape and therefore can be used in applications where induced lightning on rural or remote transmission lines present a hazard to electronic circuitry. The 704-15K36 is designed for high current short peak pulse transient applications whereas the 704-15K36T is designed for extended peak pulse transients greater than 1 millisecond.

Although designed for 28 Volt aircraft requirements, the 704-15K36 and 36T voltage levels can be special ordered for specific applications. These deviations are given a special house part number for identification. ProTek offers military screening for both devices in accordance with MIL-PRF-19500 requirements. Standard screening consists of 100% JANTX equivalent level testing per MIL-PRF-19500/500. For ordering these options, use the following suffix:

- H1 - Submodule Screening
- H2 - Submodule and Module Screening
- H3 - Submodule and Module Screening
- Module Group B & C Lot Testing

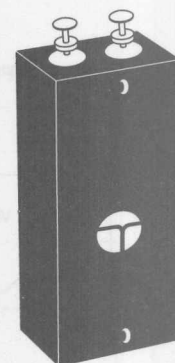
MAXIMUM RATINGS	
P_{pp} @ 25°C (See Figure 1)	15,000 Watts 10/1000 μ s Waveshape
Steady State Power Dissipation	10.0 Watts T _A = 25°C
Forward Surge Rating	300 Amps, 1/120 second @ 25°C
Repetition Rate	0.01%
Operating & Storage Temperature	-65° to +150°C
t_{Clamping} (0 Volts to V_(BR) Min.)	Unidirectional: < 1 x 10 ⁻¹² seconds
MECHANICAL CHARACTERISTICS	
Package	Molded Case
Approximate Weight	38 grams (704-15K36), 65 grams (704-15K36T)
Device Markings	Logo, Date Code & Part Number
Miscellaneous	Positive Terminal Indicated

15,000 WATTS



704-15K36

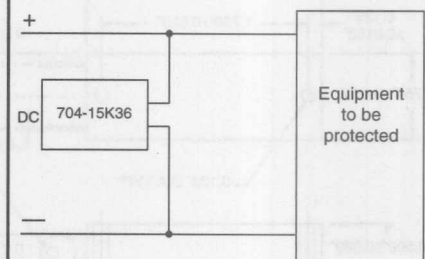
15,000 WATTS



704-15K36T

Power TVS
Components

TYPICAL DC CIRCUIT APPLICATION



ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE @ 1mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ I_{PPSM} V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ I_{PP} I_{PPM} AMPS	MAXIMUM FORWARD VOLTAGE @ 100 A, 8.3 ms V_F VOLTS DC
704-15K36	31.5	36	51	100	300	3.0
704-15K36T	31.5	36	51	500	300	15.0

FIGURE 1
PEAK PULSE POWER VS. PULSE TIME

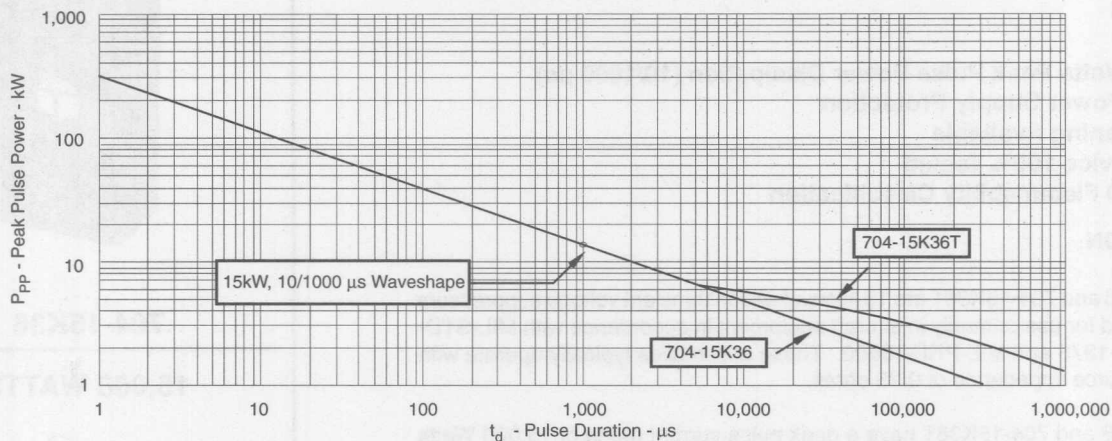


FIGURE 2
PULSE WAVE FORM

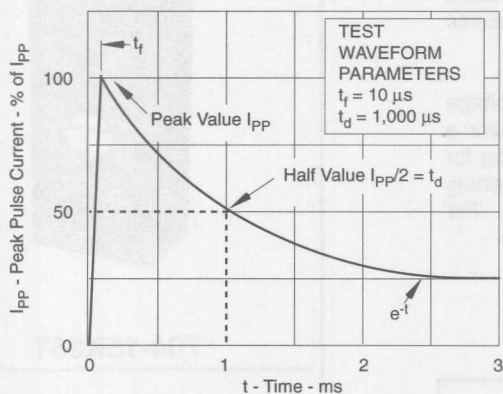
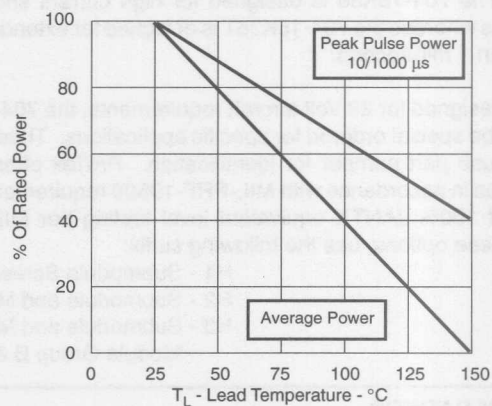
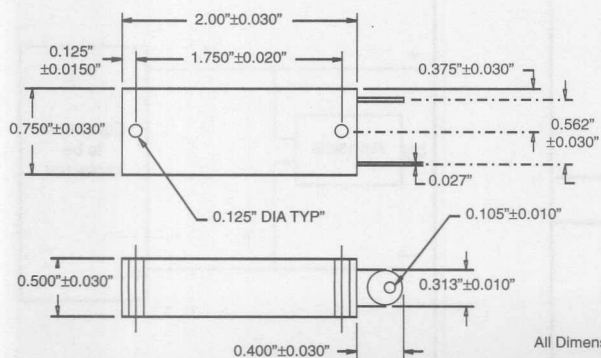


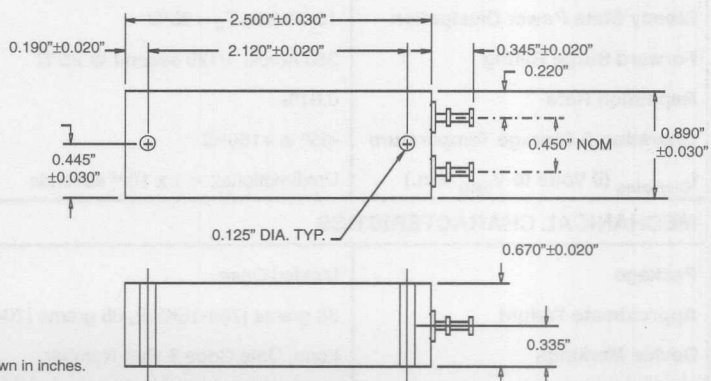
FIGURE 3
POWER DERATING CURVE



704-15K36 DIMENSIONS



704-15K36T DIMENSIONS



All Dimensions are shown in inches.



HIGH ENERGY/ EXTENDED PULSE TVS

APPLICATIONS

- Remote DC Power Supply, Base Station & Microwave Protection
- MIL-STD-1275 Power Bus Protection
- Electric Drive Motors & Controls (i.e., Turrets)
- Mobile Electronics Operating in Harsh Environments

FEATURES

- 10,000 & 30,000 Watts Peak Pulse Power Dissipation (10/1000 μ s)
- High Average (DC) Power Dissipation
- Superior Heat Dissipation Capability
- Each Device 100% Tested
- Small Package Size
- Hermetically Sealed Sub-Assemblies

DESCRIPTION

The GPZ532 and GPZ1275 are high power transient voltage suppressors (TVS) designed to provide protection against long duration switching transient threats. These heavy duty devices are constructed using hermetically sealed TVS subassemblies. Both units are suited for DC applications that include heavy duty motors, generators, or where DC power is being switched on and off at frequent intervals.

For repetitive transient events, compare the DC power dissipation rating to the average power requirements of the application. The average requirements calculated from the application should be lower than the DC power dissipation ratings shown under the "Maximum Ratings" section.

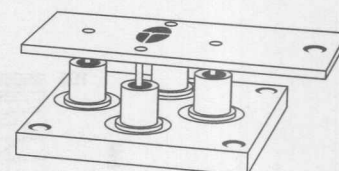
MAXIMUM RATINGS

Transient Power Dissipation (See Fig.1)	GPZ532: 10,000 Watts per 1ms GPZ1275: 30,000 Watts per 1 ms
DC Power Dissipation	350 Watts $T_C = 25^\circ\text{C}$ (derate 2.33W/ $^\circ\text{C}$)
Operating & Storage Temperature	-65° to +175°C

MECHANICAL CHARACTERISTICS

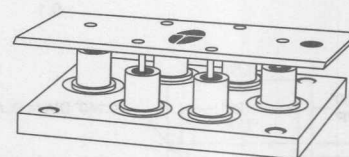
Package	Glass-to-Metal
Polarity	Anode to Case
Approximate Weight	38 grams (GPZ532), 65 grams (GPZ1275)
Device Markings	Logo, Date Code & Part Number
Miscellaneous	Sub-assemblies Hermetically Sealed

10,000 WATTS



GPZ532

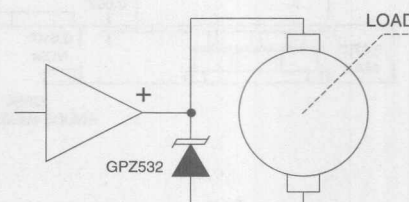
30,000 WATTS



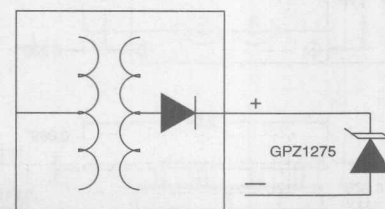
GPZ1275

Power TVS
Components

DC MOTOR APPLICATION



TRANSFORMER RECTIFIER UNIT



ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER (See Note 1)	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE		MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ I_{PPSM} V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ I_{PP} I_{PPM} AMPS
		$V_{(BR)}$ VOLTS	@ I_T A_{DC}			
GPZ532	28	32	0.20	40	50	100
GPZ1275	28	32	0.03	55	60	500

Note 1: Maximum VF = 3.5V @ 100A, 8.3ms - sine wave.

FIGURE 1
PEAK PULSE POWER VS. PULSE TIME

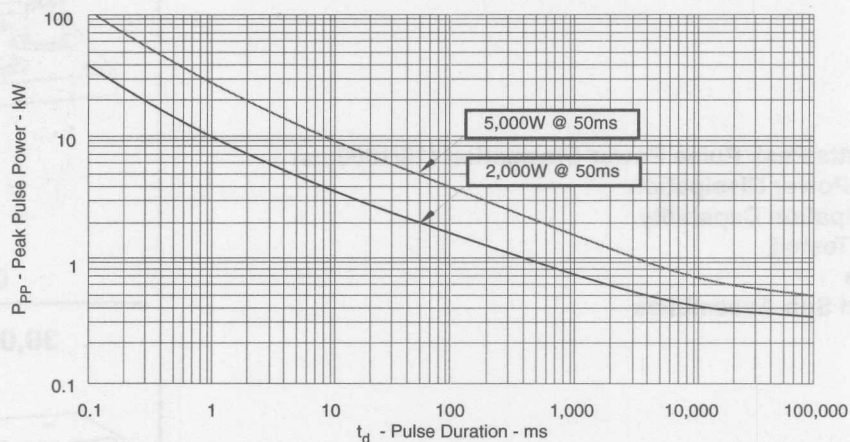


FIGURE 2
PULSE WAVE FORM

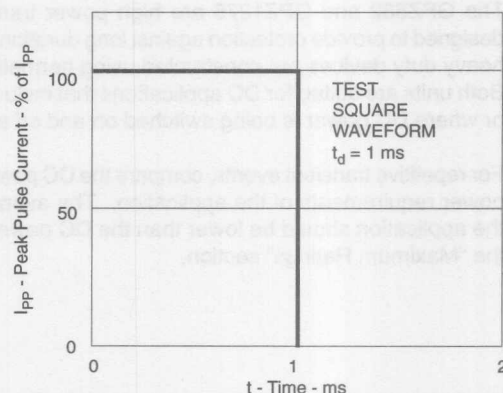
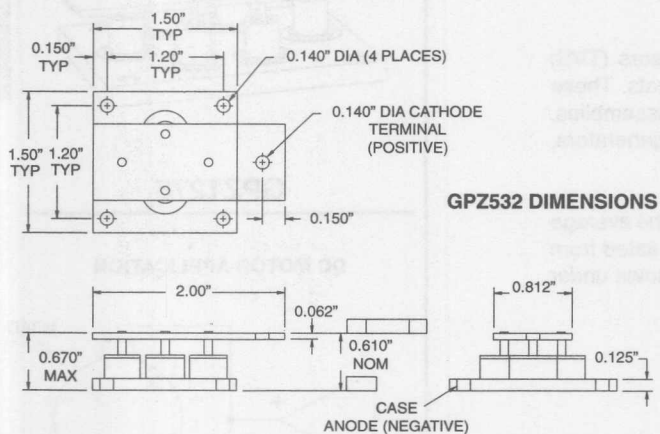
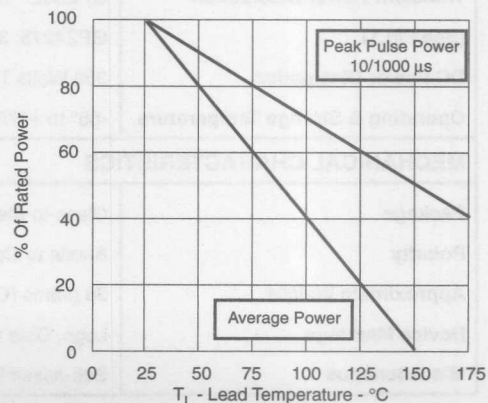
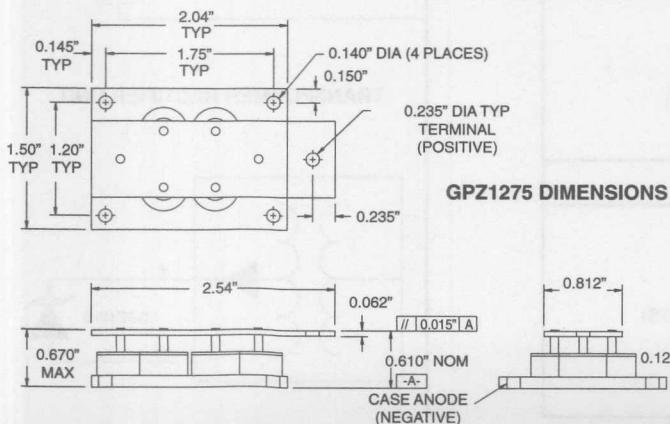


FIGURE 3
POWER DERATING CURVE



All dimensions shown are in inches only.



AC POWER BUS VOLTAGE SUPPRESSOR

APPLICATIONS

- Secondary AC Power Supply
- Aircraft & Shipboard AC Power Bus
- Heavy Duty AC Switching Power

FEATURES

- 7,500 & 15,000 Watts Peak Pulse Power Dissipation (10/1000 μ s)
- Available in Voltage Types Ranging from 8.4 to 500 Volts
- Meets the Following Military Specifications:
 - DOD-STD-1399
 - MIL-STD-2036
 - MIL-STD-704
 - MIL-PRF-STD-19500/507
- Hermetically Sealed Glass to Metal Sub-assemblies (PHP)
- Sub-assemblies are Packaged in a Molded Epoxy Case (PIP)
- Each Device 100% Tested
- UL 94V-0 Flammability Classification

DESCRIPTION

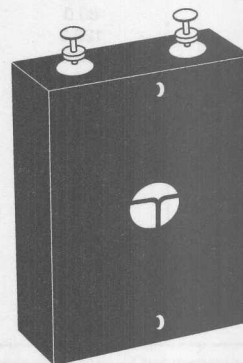
This series of devices were designed for "across-the-line" AC power protection from induced lightning, power surges and transients originating from inductive switching or power interrupt that can damage equipment or sensitive components. The PHP and PIP modules have been successfully used for both industrial and aerospace applications, including telecommunications, aircraft, shipboard, central office switching, PABS, CATV distributions, computers, distribution data processing and power supplies.

For aerospace applications, the PHP modules subassemblies are packaged in a hermetically sealed glass-to-metal package. ProTek offers the PHP series screened for aerospace requirements in accordance with MIL-PRF-19500. Standard screening consists of 100% JANTX equivalent level testing per MIL-PRF-19500/507. For ordering these options, use the following suffix:

- H1 - Submodule Screening
- H2 - Submodule and Module Screening
- H3 - Submodule and Module Screening
Module Group B & C Lot Testing

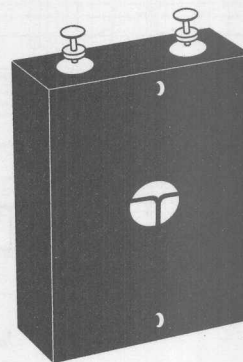
MAXIMUM RATINGS	
P_{pp} @ 25°C (See Figure 1)	7,500 & 15,000 Watts 10/1000 μ s Waveshape
Steady State Power Dissipation	7.5 Watts T _A = 50°C
Operating & Storage Temperature	-55° to +150°C
t_{Clamping} (0 Volts to V_{BR}) Min.)	Bidirectional: < 10 x 10 ⁻⁹ seconds
MECHANICAL CHARACTERISTICS	
Package: PHP Sub-Assemblies	Molded Case, Glass-to-Metal, Hermetically Sealed
PIP Sub-Assemblies	Molded Case, Glass-to-Metal
Approximate Weight	46 grams
Device Markings	Logo, Date Code & Part Number

7,500 & 15,000 WATTS



PHP SERIES

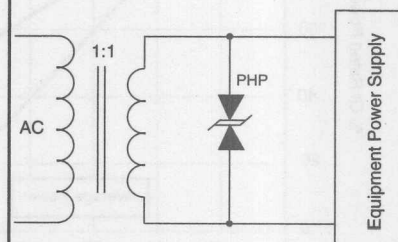
7,500 & 15,000 WATTS



PIP SERIES

Power TVS
Components

TYPICAL AC POWER APPLICATION



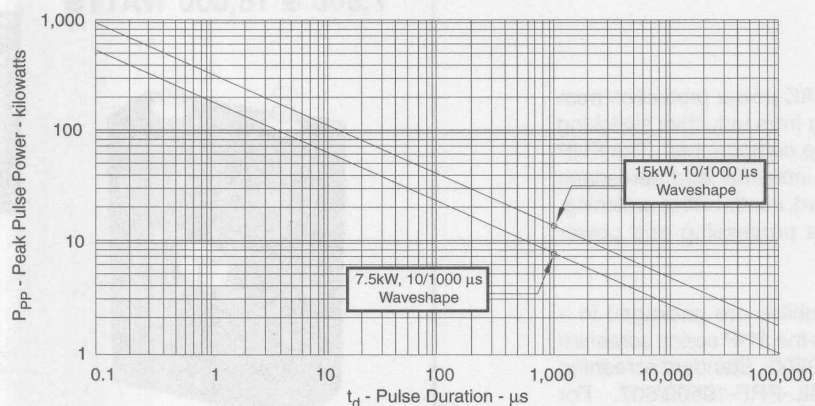
ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK TYPE NUMBER (See Note 1 & Note 2)	AVERAGE RMS VOLTAGE V_{rms} VOLTS	RATED STAND-OFF VOLTAGE V_{WM} VOLTS	MINIMUM BREAKDOWN VOLTAGE (Note 1) @ 1mA $V_{(BR)}$ VOLTS	MAXIMUM CLAMPING VOLTAGE (See Fig. 2) @ I_{PPSM} V_C VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{WM} I_D μA	MAXIMUM PEAK PULSE CURRENT (See Fig. 2) @ I_{PP} I_{PPM} AMPS	MAXIMUM PEAK PULSE POWER @ 1ms P_{PP} KWATTS
PHP 8.4	8.4	12.0	14	22	250	341	7.5
PHP 24	24.0	34.0	40	67	250	112	7.5
PHP 30	30.0	42.5	50	84	250	90	7.5
PHP 60	60.0	85.0	100	167	250	90	150
PHP 120*	120.0	170.0	200	319	250	47	150
PHP 208	208.0	295.0	347	536	250	28	150
PHP 250*	250.0	354.0	418	652	250	23	150
PHP 440	440.0	623.0	735	1138	250	13.2	150
PHP 500*	500.0	708.0	835	1292	250	11.6	150
PIP 8.4	8.4	12.0	14	22	250	341	7.5
PIP 24	24.0	34.0	40	67	250	112	7.5
PIP 30	30.0	42.5	50	84	250	90	7.5
PIP 60	60.0	85.0	100	167	250	90	150
PIP 120*	120.0	170.0	200	319	250	47	150
PIP 208	208.0	295.0	347	536	250	28	150
PIP 250*	250.0	354.0	418	652	250	23	150
PIP 440	440.0	623.0	735	1138	250	13.2	150
PIP 500*	500.0	708.0	835	1292	250	11.6	150

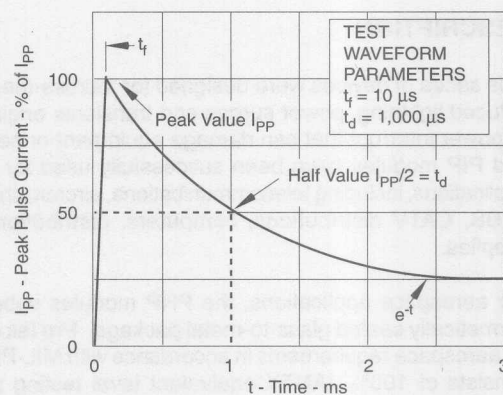
Note 1: * Recommended for marine applications. For military and aerospace applications, use PHP series. For industrial applications, use PIP series.

Note 2: The following devices have a peak pulse power rating of 7,500W for a 10/1000 μs waveshape (see Figure 1): 8.4V, 24V and 30V.

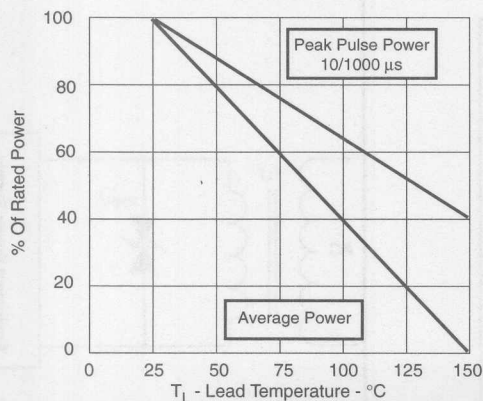
**FIGURE 1
PULSE WAVE FORM**



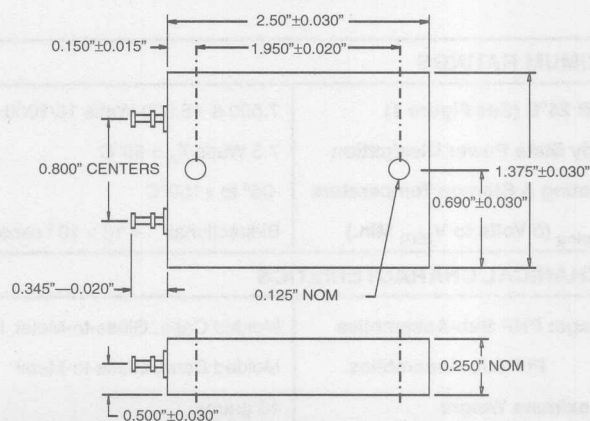
**FIGURE 2
PULSE WAVE FORM**



**FIGURE 3
POWER DERATING CURVE**



PHP & PIP DIMENSIONS



All Dimensions shown are in inches.

SECTION 6

High Power Surgebuster® Modules

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232E & 232B:	Industrial Computer Data Line Surge Protector - RS-232 6-3
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485ELC:	High Speed Ethernet Data Line Surge Protector 6-13
587B Series	120 Volt AC Power Line Surge Suppressor 6-15
587B Series	240 Volt AC Power Line Surge Suppressor 6-17
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587BxxxLP Series	240 Volt AC Low Profile AC Power Line Surge Suppressor - United States 6-21
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DESIGN CHANGES: ProTek reserves the right to discontinue product lines without notice, and that the final judgement concerning selection and specifications is the buyer's and that in furnishing engineering and technical assistance, ProTek assumes no responsibility with respect to the selection or specifications of such products.

Page	Contents
B-3	Industrial Computer Data Line Surge Protector - 500-500
B-6	4-50mA Control Line Surge Protector - 1 Line Pair
B-7	4-50mA Control Line Surge Protector - 2 Line Pairs
B-9	Data Processing Data Line Surge Protector
B-11	Digital Data Process Data Line Surge Protector
B-13	High Speed Element Data Line Surge Protector
B-15	120 Volt AC Power Line Surge Suppressor
B-17	240 Volt AC Power Line Surge Suppressor
B-19	120 Volt Low Profile AC Power Line Surge Suppressor
B-21	240 Volt AC Low Profile AC Power Line Surge Suppressor - United States
B-23	240 Volt AC Low Profile AC Power Line Surge Suppressor - European
B-25	Coaxial Video Line Surge Protector
B-27	Motor, Board and Enclosure Assembly
B-29	FBX Low Voltage Telephone Surge Protector
B-31	TELE-55E & TEL-100E Telephone Inside Surge Protector

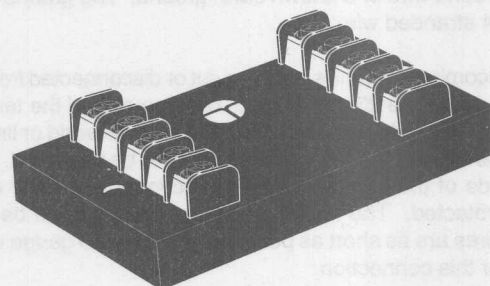
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INDUSTRIAL COMPUTER DATA LINE PROTECTOR

APPLICATIONS

- RS-232 Transmission Lines
- Category 3 Systems
- Control & Monitoring Systems
- Analog Signal Transmissions
- Telemetry Outstations



232E PACKAGE

FEATURES

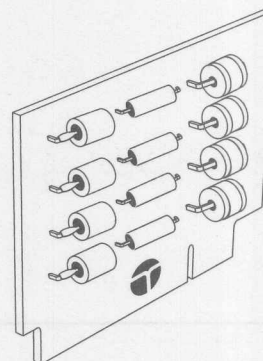
- Designed for EIA Standard RS-232 Data Lines
- Automatic Reset - Will Not Interrupt Service
- Permanent Two-Stage Line Pair Protection
- 4 Wire Line-to-Ground (Common Mode) Protection
- Subnanosecond Response Time
- Effective Against Lightning, Inductive Switching & ESD

DESCRIPTION

The 232E/B is a two-stage transient voltage protector providing primary and secondary protection against lightning, inductive switching and electrostatic discharge (ESD) transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

The 232E/B is designed to protect (4) data lines from common mode (line-to-ground) lightning or switching transients. The data lines are isolated to prevent near or far end cross talk problems.

This product can also be used on data and transmission lines, security, timing and control interface circuits. For most applications, the product should be located as close as possible to the equipment being protected. A low impedance grounding system is important to maintain a low clamping voltage between line-to-ground connections.



232B PACKAGE

Surgebuster®
Modules

MAXIMUM RATINGS @ 25° C		ELECTRICAL CHARACTERISTICS @ 25° C			
Peak Operating Line Voltage (V_{OP})	±25V	MAXIMUM CLAMPING VOLTAGE (8/20μs) @ 500A V_C VOLTS	MAXIMUM LINE THRUPUT RESISTANCE R OHMS	MAXIMUM LEAKAGE CURRENT @ 25 V_{OP} I_D μA	MAXIMUM CAPACITANCE @ 0 V, 1 MHz C pF
Operating Line Current (I_O)	200mA				
Maximum Transient Voltage	10kV				
Maximum Transient Current (8/20μs waveshape)	10kA/ Wire 40kA/ Protector				
Operating & Storage Temperature	-55° to +100°C				
Response Time	< 1 nanosecond				
Approximate Weight	232E: 142 grams 232B: 28 grams	40	12	5	2000

INSTALLATION INSTRUCTIONS

There are five (5) terminals on both the **line** and **equipment** side of the 232E, four data line terminals and one ground terminal. Both ground terminals, shown on the label, are connected internally. A single ground connection is sufficient, however, it is recommended that both ground connections be used for a lower impedance path to earth. This connection can be made through the green, AC power ground wire or a known earth ground. The ground wire should be # 14 stranded wire.

Incoming data lines are to be cut or disconnected from the equipment to insert the 232E product. The **line** side of the terminals are to be connected to data lines from the outside world or lines that carry the transient threat into the equipment to be protected. The **equipment** side of the terminals are to be connected to the equipment to be protected. The location of the product should be such that these wires are as short as possible. A #18 or 20 gauge wire can be used for this connection.

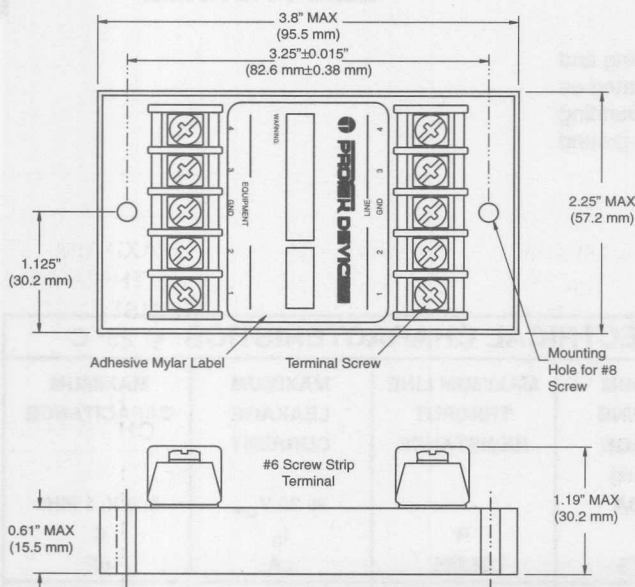
Protectors should be installed at both ends of the data lines, at the point of entry to buildings. Use the shortest possible connection to a low impedance earth ground. Proper grounding and bonding are essential for computer installation applications

The 232B circuit board requires an edge connector interface for installation. The circuit board should be located at the building interface for incoming lines from the outside world. Both the 232B and 232E can be mounted on a data line circuit panel which must be hard wired to the incoming data lines. Unprotected input lines and ground wires are to be separated from protected output lines to prevent electromagnetic coupling of noise from high transient currents on the input lines.

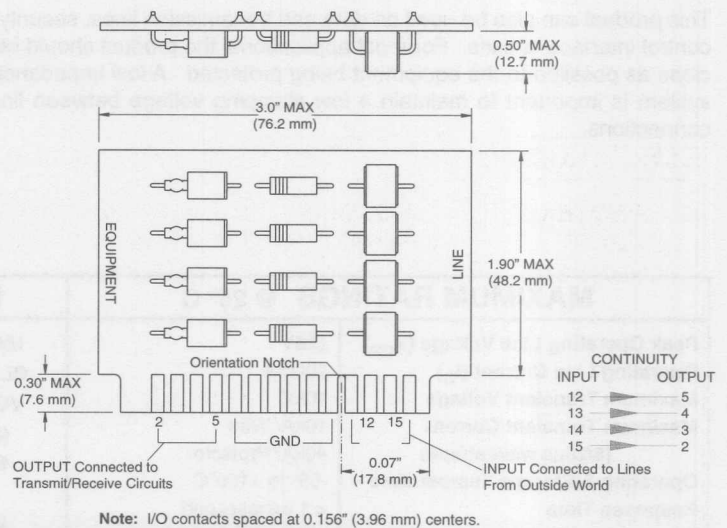
ProTek's data line protector is designed with a short circuit failure mode to give maximum protection. A fuse, fusable link, or circuit breaker is recommended for each data/signal line on the input (line) side of the protector for those applications that require an open circuit failure mode.

Caution: A low DC resistance ground may not be indicative of a good lightning ground. Lightning contains a broad spectrum of frequencies up to 1 MHz. A low impedance path to ground at the transient frequencies is necessary. A ground strap is recommended or a #6 AWG stranded wire. For wire lengths over 1.5 meters, there may be some excessive line to earth potential under severe thunderstorm conditions. For these applications, an additional protector may be necessary at the equipment interface.

232E CASE OUTLINE



232B BOARD OUTLINE



Note: I/O contacts spaced at 0.156" (3.96 mm) centers.

DUAL 4-20mA CONTROL LOOP PROTECTOR

APPLICATIONS

- Security Alarm Systems
- Industrial Control & Monitoring Systems
- Remote Tech Site Station
- Process Control Loops

FEATURES

- Meets IEC 1000-4-4 Level 4 Requirements
- Designed for 4-20mA Current Loops
- Automatic Reset - Will Not Interrupt Service
- Permanent Two-Stage Line Pair Protection
- Line-to-Ground (Common) & Line-to-Line (Differential) Protection
- Subnanosecond Response Time
- Effective Against Lightning, Inductive Switching & ESD

MAXIMUM RATINGS

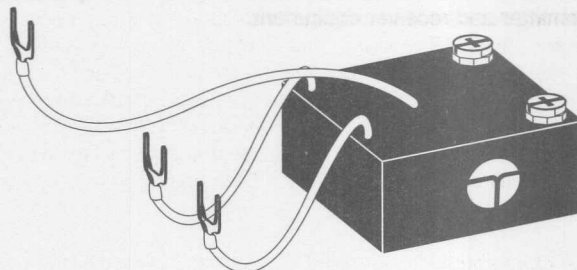
- Operating Line Current: 100mA
- Operating & Storage Temperature: -55°C to +100°C
- Transient Source Voltage: 6kV
- Transient Current (8/20μs): 10kA per Line
- Approximate Weight: 160 grams

DESCRIPTION

The 420E2 series of protection is a two-stage transient voltage protector providing primary and secondary protection against lightning, inductive switching and electrostatic discharge (ESD) transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

The 420E2 series is designed to protect 4-20mA analog control loops from differential and common mode transients. Terminals 1 and 2 are designated as the line pairs for both the line and equipment side of the protector. A transient voltage suppressor is internally connected across each line pair for differential mode protection.

This product can also be used on telephone, signal/data lines, security, timing and control interface circuits.



420E2 PACKAGE

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	MAXIMUM OPERATING LINE VOLTAGE V_{OP} ±VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{OP} I_D μA	MAXIMUM CLAMPING VOLTAGE (8/20μs) @ 2,000A V_C VOLTS	MAXIMUM CAPACITANCE @ 0 V, 1 MHz C pF	MAXIMUM LINE THRUPTUT RESISTANCE R OHMS
420E212	12.0	5.0	22	6,000	12
420E225	25.0	5.0	44	3,000	12
420E228	28.0	5.0	46	2,800	12
420E236	36.0	5.0	60	1,500	12
420E250	50.0	5.0	80	1,200	12
420E260	60.0	5.0	95	1,000	12

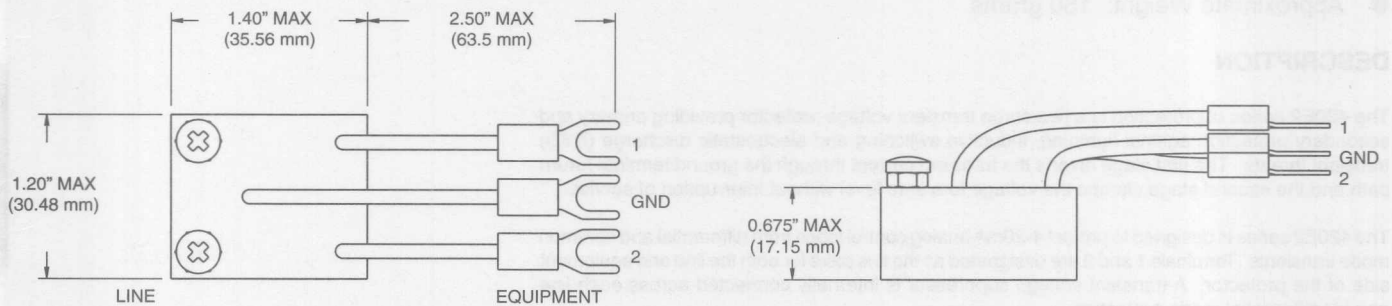
INSTALLATION INSTRUCTIONS

There are two (2) terminals on the **Line** side and three (3) wires on the **Equipment** side of this surge protection device (SPD). The ground lead is considered ground for both the input terminal and the equipment wire connections. For best results, the ground wire should be connected to a low impedance ground or the green wire AC power ground. It is recommended that a #14 stranded wire be used for this connection.

Protectors should be installed at both ends of the loop to protect the transmitter and receiver equipment.

Field (current) loops or incoming signal/data lines are to be cut or disconnected from the equipment to insert the 420E2 SPD. The **Line** side terminals of the protector are to be connected to the field loop wires. The **Equipment** side of the protector are to be connected to the protector/receiver/controller, etc. The location of the protector should be as close as possible to the equipment requiring protection. A #18 or 20 gauge wire can be used for this connection.

420E2 CASE OUTLINE



PROTECTOR PART NUMBER	MAXIMUM OPERATING LINE VOLTAGE	MAXIMUM LEAKAGE CURRENT	MAXIMUM CLAMPING VOLTAGE (10/100µs)	MAXIMUM CAPACITANCE @ 0.5 V RMS	MAXIMUM LINE THRU RESISTANCE
420E210	10.0	5.0	25	200	1.0
420E220	20.0	5.0	40	300	1.0
420E230	30.0	5.0	60	500	1.0
420E240	40.0	5.0	80	700	1.0
420E250	50.0	5.0	100	1000	1.0

TWO LINE PAIR 4-20mA CONTROL LOOP PROTECTOR

APPLICATIONS

- Multiple Process Control Loops
- Fire & Security Systems
- Petro-Chemical Plants
- Refineries & Tank Farms

FEATURES

- Designed for 4-20mA Current Loops
- Automatic Reset - Will Not Interrupt Service
- Permanent Two-Stage Line Pair Protection
- Line-to-Ground & Line-to-Line Protection (Common & Differential Mode)
- Subnanosecond Response Time
- Effective Against Lightning, Inductive Switching & ESD

MAXIMUM RATINGS

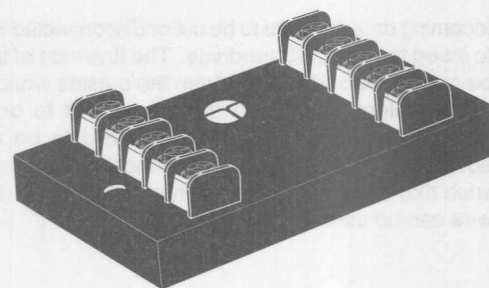
- Operating Line Current: 100mA
- Operating & Storage Temperature: -55°C to +100°C
- Transient Source Voltage: 6kV
- Transient Current (8/20μs): 10kA per Line

DESCRIPTION

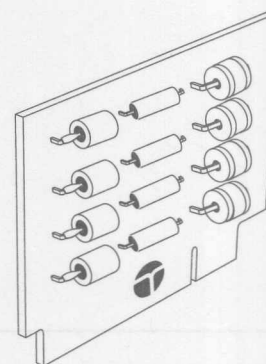
The 420LE/B Series of protection is a two-stage transient voltage protector providing primary and secondary protection against lightning, inductive switching and electrostatic discharge (ESD) transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

The 420LE/B series is designed to protect 4-20mA analog control loops from differential and common mode transients. Terminals 1 & 2 and 3 & 4 are designated as line pairs. A transient voltage suppressor is connected across each line pair for differential mode protection. Each line pair is referenced to ground.

This product can also be used on telephone, signal/data lines, security, timing and control interface circuits. For most applications, the product should be located as close as possible to the equipment being protected. A low impedance grounding system is important to maintain a low voltage clamp between the line-to-ground connection.



420LE PACKAGE



420LB PACKAGE

Surgebuster®
Modules

ELECTRICAL CHARACTERISTICS @ 25° C Ambient Temperature

PROTEK PART NUMBER	MAXIMUM OPERATING LINE VOLTAGE V_{OP} ±VOLTS	MAXIMUM LEAKAGE CURRENT @ V_{OP} I_D μA	MAXIMUM CLAMPING VOLTAGE (8/20μs) @ 2,000A V_C VOLTS	MAXIMUM CAPACITANCE @ 0 V, 1 MHz C pF	MAXIMUM LINE THRUPUT RESISTANCE R OHMS
420LE28	28.0	5.0	40	2,800	12
420LE35	35.0	5.0	60	1,500	12
420LE60	60.0	5.0	85	1,000	12
420LB28	28.0	5.0	40	2,800	12
420LB35	35.0	5.0	60	1,500	12
420LB60	60.0	5.0	85	1,000	12

INSTALLATION INSTRUCTIONS

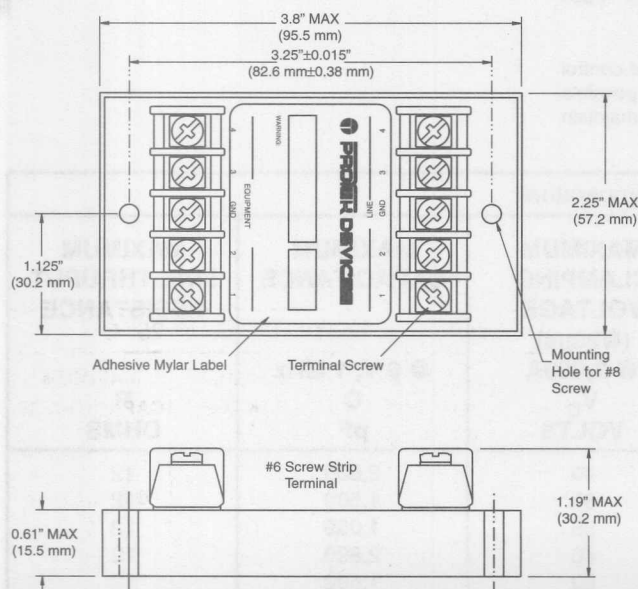
There are five (5) terminals on both the **line** and **equipment** side of the 420LE series, four data line terminals and one ground terminal. Both ground terminals, shown on the label, are connected internally. A single ground connection is sufficient, however, it is recommended that both ground connections be used for a lower impedance path to earth.

Incoming data lines are to be cut or disconnected from the equipment to insert the 420LE/B products. The **line** side of the terminals are to be connected to data lines from the outside world or lines that carry the transient threat into the equipment to be protected. The **equipment** side of the terminals are to be connected to the equipment to be protected. The location of the product should be such that these wires are as short as possible. A #18 or 20 gauge wire can be used for this connection.

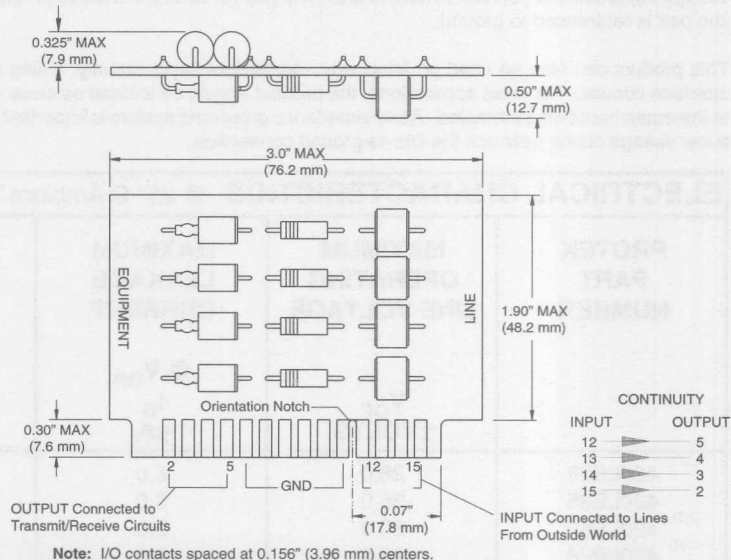
ProTek's data line protector is designed with a short circuit failure mode to give maximum protection. A fuse, fusable link, or circuit breaker is recommended for each data/signal lines on the input (line) side of the protector for those applications that require an open circuit failure mode.

Caution: A low DC resistance ground may not be indicative of a good lightning ground. Lightning contains a broad spectrum of frequencies up to 1 MHz. A low impedance path to ground at the transient frequencies is necessary. A ground strap is recommended or a #6 AWG stranded wire. For wire lengths over 1.5 meters, there may be some excessive line to earth potential under severe thunderstorm conditions.

420LE CASE OUTLINE



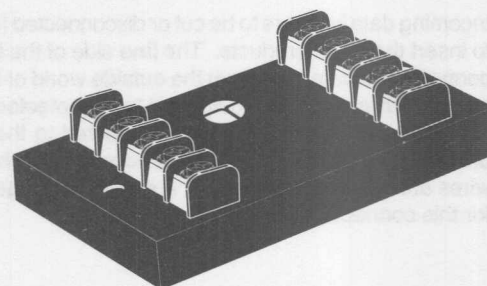
420LB BOARD OUTLINE



DATA PROCESSING DATA LINE PROTECTOR

APPLICATIONS

- Data Processing Equipment
- Long Line Transmission Systems
- Control Processing Computers
- Building Management Systems



FEATURES

- Designed for EIA Standard RS-422 Data Lines
- Automatic Reset - Will Not Interrupt Service
- Permanent Two-Stage Line Pair Protection
- Line-to-Ground & Line-to-Line Protection (Common & Differential Mode)
- Subnanosecond Response Time
- Effective Against Lightning, Inductive Switching & ESD

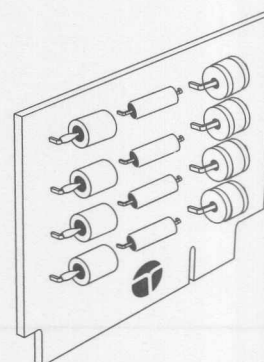
422E PACKAGE

DESCRIPTION

The 422E/B is a two-stage transient voltage protector providing primary and secondary protection against lightning, inductive switching and electrostatic discharge (ESD) transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

The 422E/B is designed to protect data lines from differential (line-to-line) and common mode (line-to-ground) transients. Terminals 1 & 2 and 3 & 4 for the 422E and pins 2 & 3 and 4 & 5 for the 422B are designated as line pairs. Each line pair is referenced to ground. A transient voltage suppressor is connected across each line pair for differential mode protection.

This product can also be used on data transmission lines, security, timing and control interface circuits. For most applications, the product should be located as close as possible to the equipment being protected. A low impedance grounding system is important to maintain a low voltage clamp between the line-to-ground connection.



422B PACKAGE

Surgebuster®
Modules

MAXIMUM RATINGS @ 25° C		ELECTRICAL CHARACTERISTICS @ 25° C				
Peak Operating Line Voltage (V_{OP})	±12 V	MAXIMUM CLAMPING VOLTAGE Line-Line	MAXIMUM CLAMPING VOLTAGE Line-Ground	MAXIMUM LINE THRUPUT RESISTANCE	MAXIMUM LEAKAGE CURRENT	MAXIMUM CAPACITANCE
Operating Line Current (I_O)	200mA	500A, 8/20μs	500A, 8/20μs		@ 12 V_{OP}	@ 0 V, 1 MHz
Maximum Transient Voltage	10kV	V_C	V_C	R	I_D	C
Maximum Transient Current (8/20μs waveshape)	10kA/ Wire	VOLTS	VOLTS	OHMS	μA	pF
Operating & Storage Temperature	-55° to +100°C					
Response Time	< 1 nanosecond					
Approximate Weight	422E: 142 grams 422B: 28 grams	24	24	12	5	5000

INSTALLATION INSTRUCTIONS

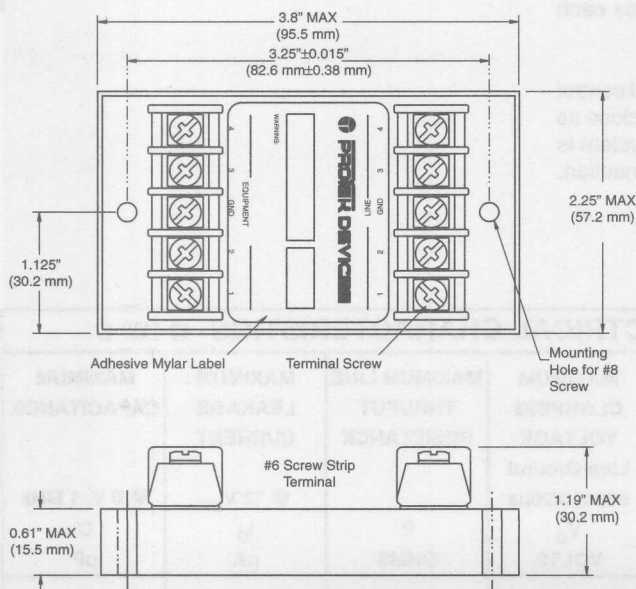
There are five (5) terminals on both the **line** and **equipment** side of the 422E series, four data line terminals and one ground terminal. Both ground terminals, shown on the label, are connected internally. A single ground connection is sufficient, however, it is recommended that both ground connections be used for a lower impedance path to earth.

Incoming data lines are to be cut or disconnected from the equipment to insert the 422E products. The **line** side of the terminals are to be connected to data lines from the outside world or lines that carry the transient threat into the equipment to be protected. The **equipment** side of the terminals are to be connected to the equipment to be protected. The location of the product should be such that these wires are as short as possible. A #18 or 20 gauge wire can be used for this connection.

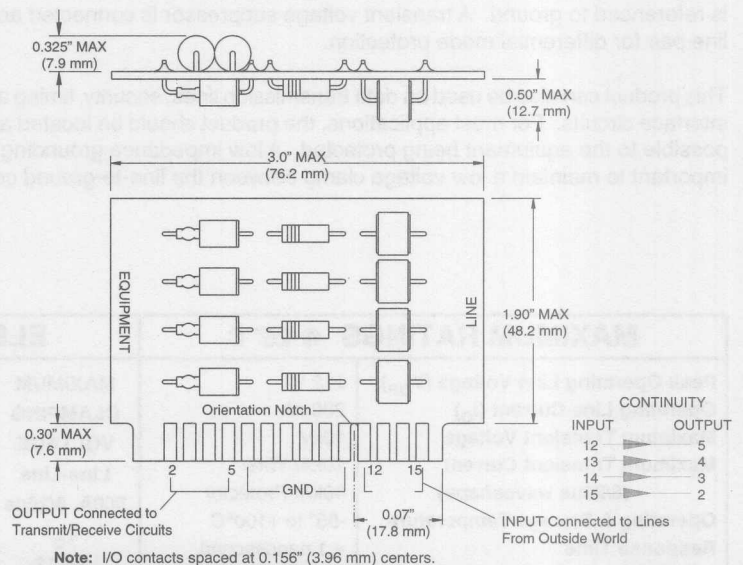
ProTek's data line protector is designed with a short circuit failure mode to give maximum protection. A fuse, fusable link, or circuit breaker is recommended for each data/signal lines on the input (line) side of the protector for those applications that require an open circuit failure mode.

Caution: A low DC resistance ground may not be indicative of a good lightning ground. Lightning contains a broad spectrum of frequencies up to 1 MHz. A low impedance path to ground a the transient frequencies is necessary. A ground strap is recommended or a #6 AWG stranded wire. For wire lengths over 1.5 meters, there may be some excessive line to earth potential under severe thunderstorm conditions.

422E CASE OUTLINE



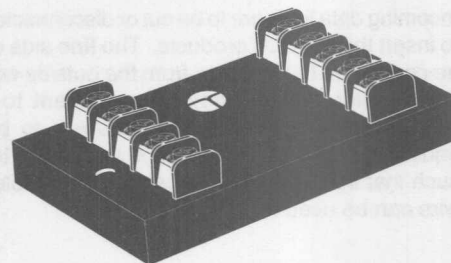
422B BOARD OUTLINE



DIGITAL DATA PROCESS DATA LINE PROTECTOR

APPLICATIONS

- Digital Process Control Loop
- Long Line Digital Systems
- Digital Transmission
- Telemetry Systems



422ELC PACKAGE

FEATURES

- Meets IEC 1000-4-5 Level 4 & 5 Requirements
- Designed for EIA Standard RS-422 Data Lines
- Low Capacitance - 25 pF
- Automatic Reset - Will Not Interrupt Service
- Permanent Two-Stage Line Pair Protection
- Line-to-Ground (Common) & Line-to-Line (Differential) Protection
- Subnanosecond Response Time
- Effective Against Lightning, Inductive Switching & ESD

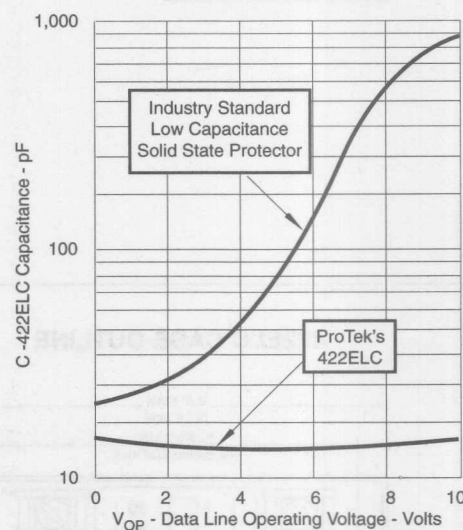
DESCRIPTION

The 422ELC is a low capacitance, two-stage transient voltage protector providing primary and secondary protection against lightning, inductive switching and electrostatic discharge (ESD) transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

The 422ELC is designed to protect data lines from differential (line-to-line) and common mode (line-to-ground) transients. Terminals 1 & 2 and 3 & 4 for the 422ELC are designated as line pairs. A transient voltage suppressor is connected across each line pair for differential mode protection.

This product can also be used on telephone, signal/data lines, security, timing and control interface circuits. For most applications, the product should be located as close as possible to the equipment being protected. A low impedance grounding system is important to maintain a low voltage clamp between the line-to-ground connection. Capacitance over the operating voltage range is important. If capacitance is nonlinear, distortion, loss of data or access to the I/O port can occur (See Fig. 1).

**FIGURE 1
LINEAR CAPACITANCE VS NON
LINEAR CAPACITANCE**



Surgebuster®
Modules

MAXIMUM RATINGS @ 25° C		ELECTRICAL CHARACTERISTICS @ 25° C				
Peak Operating Line Voltage (V _{OP})	±12 V	MAXIMUM CLAMPING VOLTAGE Line-Line	MAXIMUM CLAMPING VOLTAGE Line-Ground	MAXIMUM LINE THRUPUT RESISTANCE	MAXIMUM LEAKAGE CURRENT	TYPICAL CAPACITANCE
Operating Line Current (I _O)	200mA	500A, 8/20µs	500A, 8/20µs		@ 12 V _{OP}	@ 0-12 V, 1 MHz
Maximum Transient Voltage	20kV	V _C	V _C	R	I _D	C
Maximum Transient Current (8/20µs waveshape)	10kA/ Wire	VOLTS	VOLTS	OHMS	µA	pF
Operating & Storage Temperature	-55° to +100°C	30	30	12	1	25
Response Time	< 1 nanosecond					
Approximate Weight	142 grams					

INSTALLATION INSTRUCTIONS

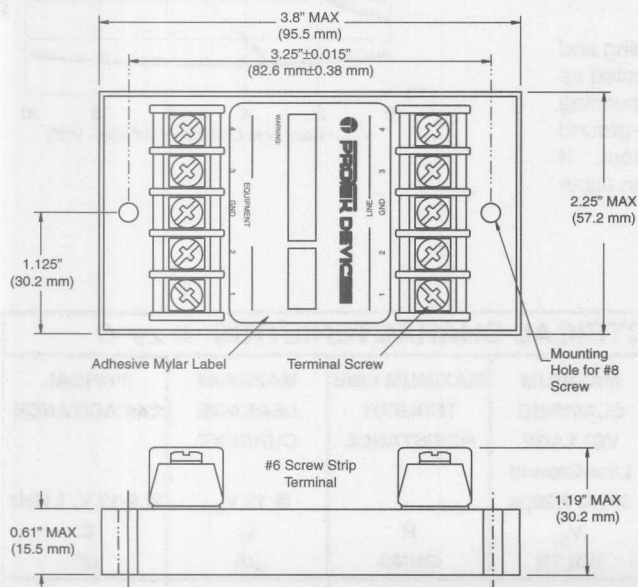
There are five (5) terminals on both the **line** and **equipment** side of the SPD, four data line terminals and one ground terminal. Both ground terminals, shown on the label, are connected internally. A single ground connection is sufficient, however, it is recommended that both ground connections be used for a lower impedance path to earth.

Incoming data lines are to be cut or disconnected from the equipment to insert the 422ELC products. The **line** side of the terminals are to be connected to data lines from the outside world or lines that carry the transient threat into the equipment to be protected. The **equipment** side of the terminals are to be connected to the equipment to be protected. The location of the product should be such that these wires are as short as possible. A #18 or 20 gauge wire can be used for this connection.

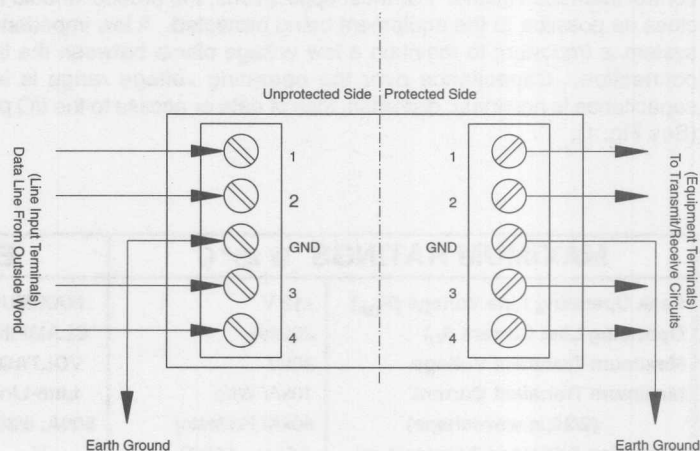
ProTek's data line protector is designed with a short circuit failure mode to give maximum protection. A fuse, fusable link, or circuit breaker is recommended for each data/signal lines on the input (line) side of the protector for those applications that require an open circuit failure mode.

Caution: A low DC resistance ground may not be indicative of a good lightning ground. Lightning contains a broad spectrum of frequencies up to 1 MHz. A low impedance path to ground at the transient frequencies is necessary. A ground strap is recommended or a #6 AWG stranded wire. For wire lengths over 1.5 meters, there may be some excessive line to earth potential under severe thunderstorm conditions.

422ELC CASE OUTLINE



INSTALLATION DIAGRAM

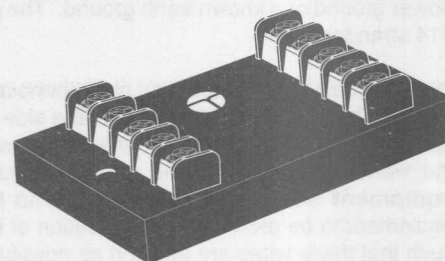


Note: Both ground terminals are common. Use second ground wire to reduce impedance on long runs to earth ground connections

HIGH SPEED ETHERNET DATA LINE PROTECTOR

APPLICATIONS

- RS-485 Serial Communication Lines
- Category 5 Protection
- Token Ring, Ethernet Systems
- ISDN Systems
- Video Transmission Systems



485ELC PACKAGE

FEATURES

- Meets IEC 1000-4-5, Level 4 & 5 Requirements
- Designed for EIA Standard RS-485 Data Lines
- Low Capacitance - 25 pF
- Automatic Reset - Will Not Interrupt Service
- Permanent Two-Stage Protection
- Line-to-Ground (Common) & Line-to-Line (Differential) Protection
- Subnanosecond Response Time
- Effective Against Lightning, Inductive Switching & ESD

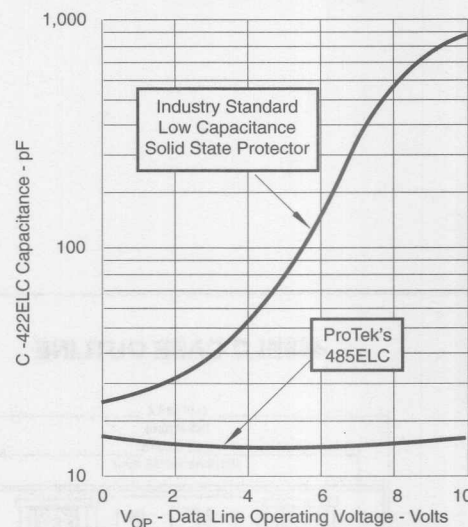
DESCRIPTION

The 485ELC is a low capacitance, two-stage transient voltage protector providing primary and secondary protection against lightning, inductive switching and electrostatic discharge (ESD) transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

The 485ELC is designed to protect data lines from differential (line-to-line) and common mode (line-to-ground) transients. Terminals 1 & 2 and 3 & 4 for the 422ELC are designated as line pairs. A transient voltage suppressor is connected across each line pair for differential mode protection.

This product can also be used for data transmission, timing and control interface circuits. For most applications, the product should be located as close as possible to the equipment being protected. A low impedance grounding system is important to maintain a low clamping voltage between the line-to-ground connection. Capacitance over the operating voltage range is important. If capacitance is nonlinear, distortion, loss of data or access to the I/O port can occur (See Fig. 1).

**FIGURE 1
LINEAR CAPACITANCE VS NON
LINEAR CAPACITANCE**



Surgebuster®
Modules

MAXIMUM RATINGS @ 25° C		ELECTRICAL CHARACTERISTICS @ 25° C				
Peak Operating Line Voltage (V _{OP})	±7 V	MAXIMUM CLAMPING VOLTAGE	MAXIMUM CLAMPING VOLTAGE	MAXIMUM LINE THRUPUT RESISTANCE	MAXIMUM LEAKAGE CURRENT	TYPICAL CAPACITANCE
Operating Line Current (I _O)	250mA	Line-Line	Line-Ground			
Maximum Transient Voltage	20kV	500A, 8/20μs	500A, 8/20μs		@ 7 V _{OP}	@ 0-7 V, 1 MHz
Maximum Transient Current (8/20μs waveshape)	10kA/ Wire	V _C	V _C	R	I _D	C
	40kA/ Protector	VOLTS	VOLTS	OHMS	μA	pF
Operating & Storage Temperature	-55° to +100°C	20	20	12	10	25
Response Time	< 1 nanosecond					
Approximate Weight	142 grams					

INSTALLATION INSTRUCTIONS

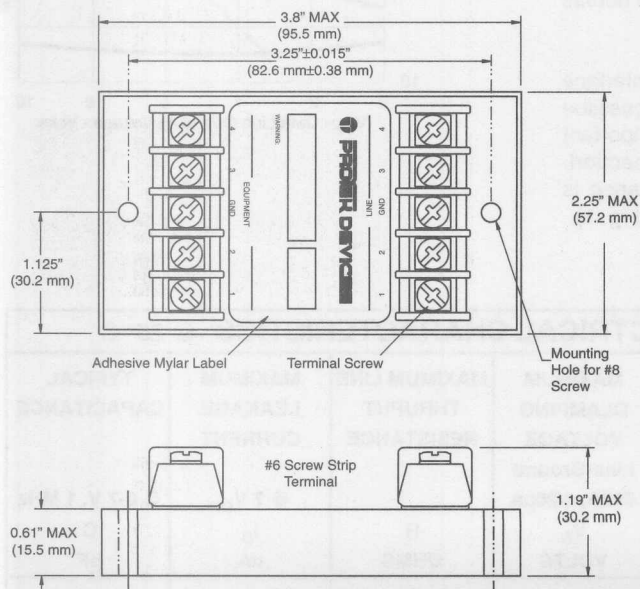
There are five (5) terminals on both the **line** and **equipment** side of the SPD, four data line terminals and one ground terminal. Both ground terminals, shown on the label, are connected internally. A single ground connection is sufficient, however, it is recommended that both ground connections be used for a lower impedance path to earth. This connection can be made through the green wire AC power ground or a known earth ground. The ground wire should be #14 stranded wire.

Incoming data lines are to be cut or disconnected from the equipment to insert the 485ELC products. The **line** side of the terminals are to be connected to data lines from the outside world or lines that carry the transient threat into the equipment to be protected. The **equipment** side of the terminals are to be connected to the equipment to be protected. The location of the product should be such that these wires are as short as possible. A #18 or 20 gauge wire can be used for this connection.

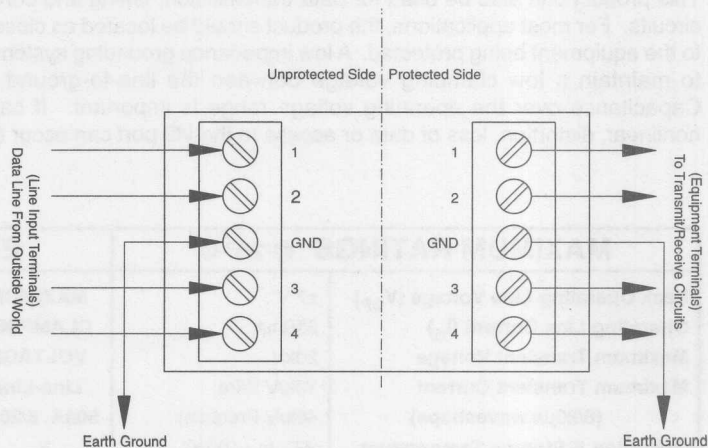
ProTek's data line protector is designed with a short circuit failure mode to give maximum protection. A fuse, fusable link, or circuit breaker is recommended for each data/signal lines on the input (line) side of the protector for those applications that require an open circuit failure mode.

Caution: A low DC resistance ground may not be indicative of a good lightning ground. Lightning contains a broad spectrum of frequencies up to 1 MHz. A low impedance path to ground at the transient frequencies is necessary. A ground strap is recommended or a #6 AWG stranded wire. For wire lengths over 1.5 meters, there may be some excessive line to earth potential under severe thunderstorm conditions.

485ELC CASE OUTLINE



INSTALLATION DIAGRAM



120 VOLT AC POWER LINE SURGE SUPPRESSOR

APPLICATIONS

- Hard Wired Equipment AC Power Protection
- Load Side Distribution Systems
- Secondary Protection for Light Industrial AC Power

FEATURES

- Meets IEC 1000-4-5 Industry Requirements
- Meets ANSI/IEEE C62.41 Requirements
- Differential Mode Protection
- Low Clamping Voltage
- Nanosecond Response Time
- Long Life & Maintenance Free
- Each Device 100% Tested
- CSA & NRTL Certified

MAXIMUM RATINGS

- Line Voltage: 130 VAC
- Line Current:
 - 587B051: 5.0A
 - 587B151: 15.0A
 - 587B201: 20.0A
 - 587B301: 30.0A (Line-to-Neutral Only)
- Transient Voltage: 6,000V Peak
- Transient Current: 3,000A Peak
- Leakage Current @ 120 VAC:
 - Line-to-Neutral: 1.0mA
 - Neutral-to-Ground: 0.5mA
- Operating & Storage Temperatures: -40°C to +85°C

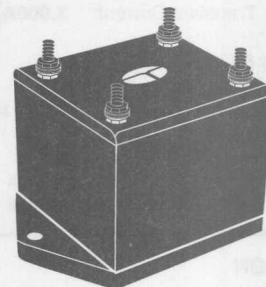
DESCRIPTION

The 587B series of 120 Volt AC surge suppressors is designed for use by the OEM, the equipment installer and/or maintenance contractor. These epoxy encapsulated modules employ a three-stage, patented, solid state technology which was originally developed for aerospace applications. This multistage TVS technology has proven to be the most cost effective and reliable method in protecting sensitive electronic equipment from over voltage transients.

This device, a unique low clamping voltage transient suppressor, is designed to protect AC powered equipment from the 6,000 Volt peak open circuit voltage and 3,000 Amp short circuit current as defined in ANSI/IEEE C62.41, Category B.

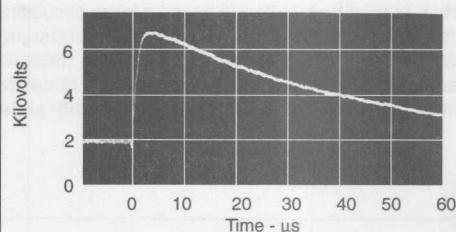
In addition, the 587B series offers a high degree of protection against 120 VAC line noise. It is ideal for protecting 400 Volt rated components because the solid state TVS technology assures that line-to-neutral voltages will not exceed 350 Volts. While the modules are designed for transient voltage protection, the advanced patented circuitry will also attenuate the amplitude and slow the rate of rise of high frequency noise. The 587B Modules include differential mode low-pass filters which are effective in reducing interference from line to equipment and are effective in reducing equipment generated noise to meet FCC, VDE and CSA interference requirements.

IEC 1000-4 COMPATIBLE

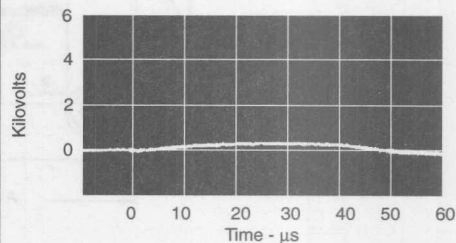


U.S. PATENT 4,563,720

**FIGURE 1
TRANSIENT VOLTAGE THREAT
CONDITION**



**FIGURE 2
TYPICAL CLAMPING ACTION
OF A 15 AMP MODULE**



Figures 1 and 2 are photographs of digitized waveforms showing the typical clamping action of a 15 ampere module. A 12 ohm resistor is used to represent a 10 Amp equipment load. The load is then subjected to the ANSI/IEEE C62.41 Category B test conditions (6,000V/3,000A). These photographs contrast the effect on equipment with and without the protector.

Surgebuster®
Modules

ELECTRICAL CHARACTERISTICS @ 25°C Ambient Temperature

Operating Line Voltage: 130 VAC Max	RESPONSE TO TRANSIENT VOLTAGES							
Maximum Line Current: 587B051, 5A 587B151, 15A 587B201, 20A 587B301, 30A	Clamping			Test Condition				
	PROTECTION MODE	MAXIMUM CLAMPING VOLTAGE	OPEN CIRCUIT VOLTAGE @ 1.2 x 50 μs	OPEN CIRCUIT VOLTAGE @ 8 x 20 μs				
	DIFFERENTIAL (Line to Neutral)	295V 350V	1,000V 6,000V	500A 3,000A				
MAXIMUM RATINGS								
Transient Voltage: 6,000V _{peak}								
Transient Current: 3,000A _{peak}								
Storage & Operating Case Temperature (measured at center of mounting surface): -40°C to +85°C								
Current Leakage at 120 VAC Line to Neutral: 1.0mA Neutral to Ground: 0.5mA	COMMON (Neutral to Ground)			500V 650V	1,000V 6,000V			500A 3,000A
	FILTER CHARACTERISTICS (Noise Attenuation)							
	Frequency (MHz)	0.15	0.5	1.0	5.0	10	30	
Common Mode Attenuation (dB)	10	25	35	55	50	40		
Differential Mode Attenuation (dB)	30	55	55	55	50	45		

OPERATION

For maximum effectiveness, the protector should be installed directly after the AC line on/off switch and fuse. This will protect the electronics from the AC line switch arcing and the severe transients caused by a fuse clearing.

Some heat is produced when operating at full rated current load, and heat sinking may be required to maintain case temperatures below 85°C. The case temperature is measured at the center of the mounting surface. The unit should not be mounted to a low combusting temperature material such as wood.

High energy transients will cause a large circulating current in the AC input line (2,500A is possible). To prevent electromagnetic coupling, the AC line on the input side of the protector must be dressed away from other wiring and magnetic shielding may be required. In addition, the electrical service must be connected to a low impedance earth ground.

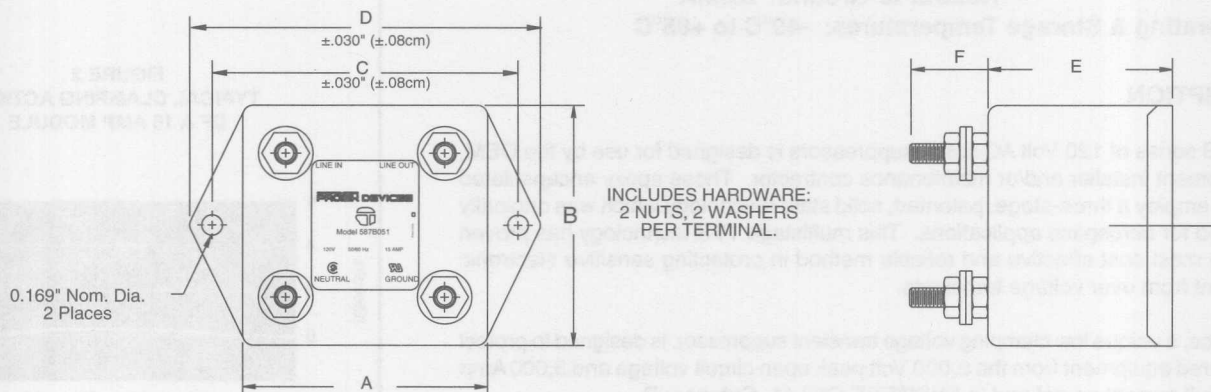
ARRESTER DEFINITIONS

Clamping Voltage: The clamping voltage of an arrester is the voltage that appears across its terminals during conduction of a transient current.

Standard Wave: The waveshape of a surge current or voltage is designated by a combination of two numbers. The first number is for the time of the wave front expressed in microseconds from zero to the peak of the wave. The second number is for the time of the wavetail also expressed in microseconds from zero to the instant that the wavetail reaches one-half of the crest or peak value. Example, 8/20 µs wave.

Transient Current: The transient current of an arrester is the peak surge current which flows through the arrester when voltage clamping occurs.

587B DIMENSIONS & CASE OUTLINE



PROTEK PART NUMBER	MAXIMUM LINE CURRENT	CASE (INCHES)						CASE (CENTIMETERS)						APPROX. WEIGHT IN GRAMS	TERMINAL THREADS
		A	B	C	D	E	F	A	B	C	D	E	F		
587B051	5A	2	2	2.5	3.0	1.5	0.6	5.08	5.08	6.35	7.62	3.82	1.52	250	#8-32
587B151	15A	3	2	3.5	4.0	1.5	0.6	7.62	5.08	8.9	10.2	3.82	1.52	500	#8-32
587B201	20A	3	3	3.5	4.0	1.5	0.6	7.62	7.62	8.9	10.2	3.82	1.52	750	M5
587B301	30A	3	3	3.5	4.0	1.5	0.6	7.62	7.62	8.9	10.2	3.82	1.52	850	M5

240 VOLT AC POWER LINE SURGE SUPPRESSOR

APPLICATIONS

- Hard Wired Equipment AC Power Protection
- Load Side Distribution Systems
- Secondary Protection for Light Industrial AC Power

FEATURES

- Meets IEC 1000-4-5 Industry Requirements
- Meets ANSI/IEEE C62.41 Requirements
- Differential Mode Protection
- Low Clamping Voltage
- Nanosecond Response Time
- Long Life & Maintenance Free
- Each Device 100% Tested
- CSA & NRTL Certified

MAXIMUM RATINGS

- Line Voltage: 240 VAC
- Line Current:
 - 587B062: 6.0A
 - 587B162: 16.0A
 - 587B302: 30.0A
- Transient Voltage: 6,000V Peak
- Transient Current: 3,000A Peak
- Leakage Current @ 240 VAC:
 - Line-to-Neutral: 1.0mA
 - Line to Neutral Voltage: 750V pk
- Operating & Storage Temperatures: -40°C to +85°C

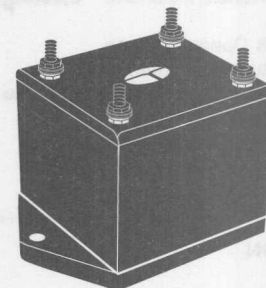
DESCRIPTION

The 587B series of 240 Volt AC surge suppressors is designed for use by the OEM, the equipment installer and/or maintenance contractor. These epoxy encapsulated modules employ a three-stage, patented, solid state technology which was originally developed for aerospace applications. This multistage TVS technology has proven to be the most cost effective and reliable method in protecting sensitive electronic equipment from over voltage transients.

This device, a unique low clamping voltage transient suppressor, is designed to protect AC powered equipment from the 6,000 Volt peak open circuit voltage and 3,000 Amp short circuit current as defined in ANSI/IEEE C62.41, Category B.

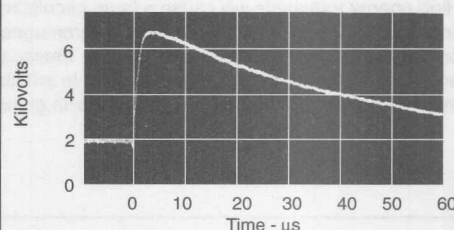
In addition, the 587B series offers a high degree of protection against 240 VAC line noise. It is ideal for protecting 800 Volt rated component because the solid state TVS technology assures that line-to-neutral voltages will not exceed 800 Volts. While the modules are designed for transient voltage protection, the advanced patented circuitry will also attenuate the amplitude and slow the rate of rise of high frequency noise. The 587B Modules include differential mode low-pass filters which are effective in reducing interference from line to equipment and are effective in reducing equipment generated noise to meet FCC, VDE and CSA interference requirements.

IEC 1000-2 COMPATIBLE

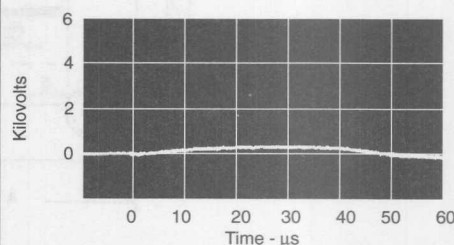


U.S. PATENT 4,563,720

**FIGURE 1
TRANSIENT VOLTAGE THREAT
CONDITION**



**FIGURE 2
TYPICAL CLAMPING ACTION
OF A 16 AMP MODULE**



Figures 1 and 2 are photographs of digitized waveforms showing the typical clamping action of a 16 ampere module. A 12 ohm resistor is used to represent a 10 Amp equipment load. The load is then subjected to the ANSI/IEEE C62.41 Category B test conditions (6,000V/3,000A). These photographs contrast the effect on equipment with and without the protector.

Surgebuster®
Modules

ELECTRICAL CHARACTERISTICS @ 25°C Ambient Temperature					
Operating Line Voltage: 240 VAC Max		RESPONSE TO TRANSIENT VOLTAGES			
Maximum Line Current: 587B062, 6A 587B162, 16A 587B302, 30A		Clamping		Test Condition	
		PROTECTION MODE	MAXIMUM CLAMPING VOLTAGE	OPEN CIRCUIT VOLTAGE @ 1.2 x 50 µs	OPEN CIRCUIT VOLTAGE @ 8 x 20 µs
MAXIMUM RATINGS		DIFFERENTIAL (Line to Neutral)	800V	6,000V	3,000A
Transient Voltage: 6,000V_{peak}		COMMON (Neutral to Ground)	N/A	N/A	N/A
Transient Current: 3,000A_{peak}		FILTER CHARACTERISTICS (Noise Attenuation)			
Storage & Operating Case Temperature (measured at center of mounting surface): -40°C to +85°C		Frequency (MHz)	0.15	0.5	1.0
Current Leakage at 240 VAC		Common Mode Attenuation (dB)	N/A	N/A	N/A
Line to Neutral: 1.0mA		Differential Mode Attenuation (dB)	30	55	55
Neutral to Ground: N/A				55	50
					45

OPERATION

For maximum effectiveness, the protector should be installed directly after the AC line on/off switch and fuse. This will protect the electronics from the AC line switch arcing and the severe transients caused by a fuse clearing.

Some heat is produced when operating at full rated current load, and heat sinking may be required to maintain case temperatures below 85°C. The case temperature is measured at the center of the mounting surface. The unit should not be mounted to a low combusting temperature material such as wood.

High energy transients will cause a large circulating current in the AC input line (2,500A is possible). To prevent electromagnetic coupling, the AC line on the input side of the protector must be dressed away from other wiring and magnetic shielding may be required. In addition, the electrical service must be connected to a low impedance earth ground.

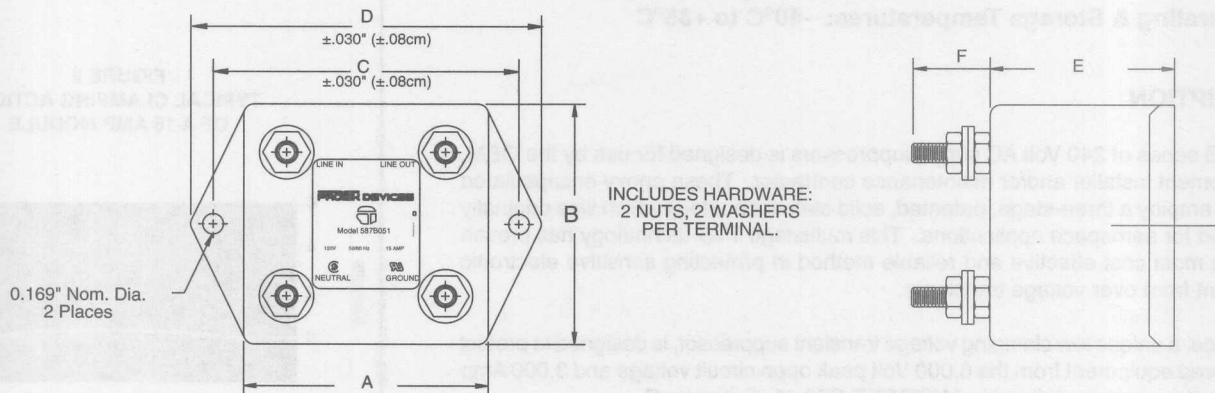
ARRESTER DEFINITIONS

Clamping Voltage: The clamping voltage of an arrester is the voltage that appears across its terminals during conduction of a transient current.

Standard Wave: The waveshape of a surge current or voltage is designated by a combination of two numbers. The first number is for the time of the wave front expressed in microseconds from zero to the peak of the wave. The second number is for the time of the wavetail also expressed in microseconds from zero to the instant that the wavetail reaches one-half of the crest or peak value. Example, 8/20 µs wave.

Transient Current: The transient current of an arrester is the peak surge current which flows through the arrester when voltage clamping occurs.

587B DIMENSIONS & CASE OUTLINE



PROTEK PART NUMBER	MAXIMUM LINE CURRENT	CASE (INCHES)						CASE (CENTIMETERS)						APPROX. WEIGHT IN GRAMS	TERMINAL THREADS
		A	B	C	D	E	F	A	B	C	D	E	F		
587B062	6A	3	3	3.5	4.0	1.5	0.6	5.08	5.08	8.9	10.2	3.82	1.52	750	M5
587B162	16A	3	3	3.5	4.0	1.5	0.6	7.62	5.08	8.9	10.2	3.82	1.52	750	M5
587B302	30A	3	3	3.5	4.0	1.5	0.6	7.62	7.62	8.9	10.2	3.82	1.52	750	M5



LOW PROFILE 120V AC POWER LINE SURGE SUPPRESSOR

APPLICATIONS

- Hard Wired Equipment AC Power Protection
- Load Side Distribution Systems
- Secondary Protection for Light Industrial AC Power

FEATURES

- Meets IEC 1000-4-5 Industry Requirements
- Meets ANSI/IEEE C62.41 Requirements
- Listed to CSA/NRTL, File LR65240-15
- Differential & Common Mode Protection
- Low Clamping Voltage
- Nanosecond Response Time
- Long Life & Maintenance Free
- Each Device 100% Tested

MAXIMUM RATINGS

- Line Voltage: 130 VAC
- Line Current:
 - 587B051LP: 5.0A
 - 587B101LP: 10.0A
 - 587B151LP: 15.0A
 - 587B201LP: 20.0A
 - 587B301LP: 30.0A
- Transient Voltage: 6,000V Peak
- Transient Current: 3,000A Peak
- Leakage Current @ 120 VAC:
 - Line-to-Neutral: 1.0mA
 - Neutral-to-Ground: 0.5mA
- Operating & Storage Temperatures: -40°C to 85°C

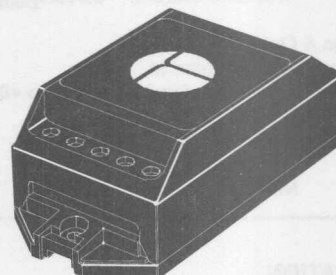
DESCRIPTION

The 587B low profile (LP) series of 120 Volt AC surge suppressors is designed for use by the OEM, the equipment installer and/or maintenance contractor. These modules employ a three-stage, patented, solid state technology which was originally developed for aerospace applications. This multistage TVS technology has proven to be the most cost effective and reliable method in protecting sensitive electronic equipment from over voltage transients.

This device, a unique low clamping voltage transient suppressor, is designed to protect AC powered equipment from the 6,000 Volt peak open circuit voltage and 3,000 Amp short circuit current as defined in ANSI/IEEE C62.41, Category B.

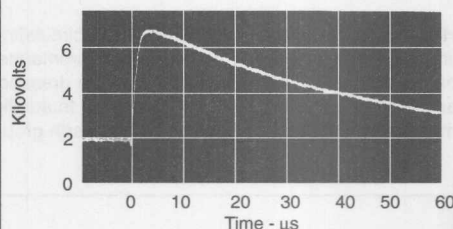
In addition, the 587B low profile series offers a high degree of protection against 120 VAC line noise. It is ideal for protecting 400 Volt rated components because the solid state TVS technology assures that line-to-neutral voltages will not exceed 350 Volts. While the modules are designed for transient voltage protection, the advanced patented circuitry will also attenuate the amplitude and slow the rate of rise of high frequency noise. The 587BxxxLP Modules include common mode and differential mode low-pass filters which are effective in reducing interference from line to equipment and are effective in reducing equipment generated noise to meet FCC, VDE and CSA interference requirements.

IEC 1000-4 COMPATIBLE

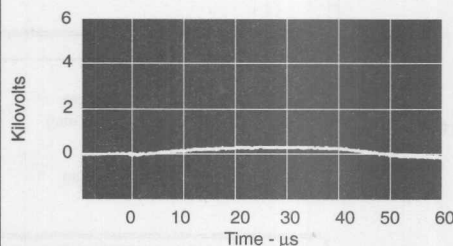


U.S. PATENT 4,563,720

**FIGURE 1
TRANSIENT VOLTAGE THREAT
CONDITION**



**FIGURE 2
TYPICAL CLAMPING ACTION
OF A 15 AMP MODULE**



Figures 1 and 2 are photographs of digitized waveforms showing the typical clamping action of a 15 ampere module. A 12 ohm resistor is used to represent a 10 Amp equipment load. The load is then subjected to the ANSI/IEEE C62.41 Category B test conditions (6,000V/3,000A). These photographs contrast the effect on equipment with and without the protector.

Surgebuster®
Modules

ELECTRICAL CHARACTERISTICS @ 25°C Ambient Temperature

Operating Line Voltage: 130 VAC Max Maximum Line Current: 587B051LP, 5A 587B101LP, 10A 587B151LP, 15A 587B201LP, 20A 587B301LP, 30A	RESPONSE TO TRANSIENT VOLTAGES			
	Clamping		Test Condition	
	PROTECTION MODE	MAXIMUM CLAMPING VOLTAGE	OPEN CIRCUIT VOLTAGE @ 1.2 x 50 µs	OPEN CIRCUIT VOLTAGE @ 8 x 20 µs
MAXIMUM RATINGS Transient Voltage: 6,000V_{peak} Transient Current: 3,000A_{peak} Storage & Operating Case Temperature (measured at center of mounting surface): -40°C to +85°C Current Leakage at 120 VAC Line to Neutral: 1.0mA Neutral to Ground: 0.5mA	DIFFERENTIAL (Line to Neutral)	295V 330V	1,000V 6,000V	500A 3,000A
	COMMON (Neutral to Ground) (Line to Ground)	500V 500V 500V	1,000V 6,000V	500A 3,000A

OPERATION

For maximum effectiveness, the protector should be installed directly after the AC line on/off switch and fuse. This will protect the electronics from the AC line switch arcing and the severe transients caused by a fuse clearing.

Some heat is produced when operating at full rated current load, and heat sinking may be required to maintain case temperatures below 85°C. The case temperature is measured at the center of the mounting surface. The unit should not be mounted to a low combusting temperature material such as wood.

High energy transients will cause a large circulating current in the AC input line (2,500A is possible). To prevent electromagnetic coupling, the AC line on the input side of the protector must be dressed away from other wiring and magnetic shielding may be required. In addition, the electrical service must be connected to a low impedance earth ground.

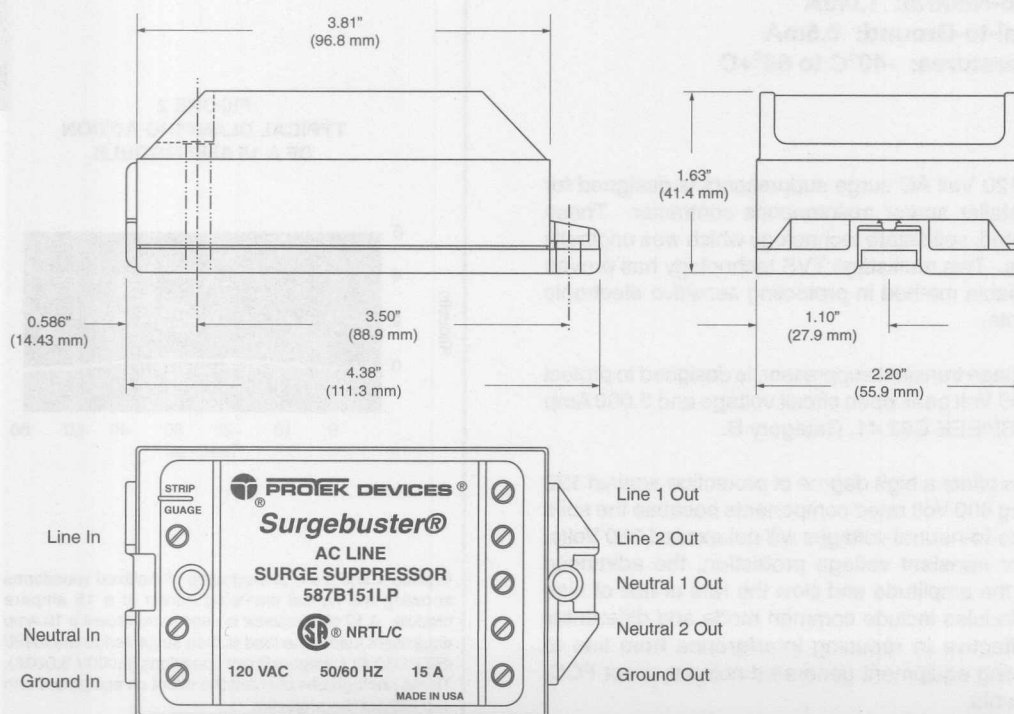
ARRESTER DEFINITIONS

Clamping Voltage: The clamping voltage of an arrester is the voltage that appears across its terminals during conduction of a transient current.

Standard Wave: The waveshape of a surge current or voltage is designated by a combination of two numbers. The first number is for the time of the wave front expressed in microseconds from zero to the peak of the wave. The second number is for the time of the wavetail also expressed in microseconds from zero to the instant that the wavetail reaches one-half of the crest or peak value. Example, 8/20 µs wave.

Transient Current: The transient current of an arrester is the peak surge current which flows through the arrester when voltage clamping occurs.

587BLP DIMENSIONS & CASE OUTLINE



LOW PROFILE 240V AC POWER LINE SURGE SUPPRESSOR

APPLICATIONS

- Hard Wired Equipment AC Power Protection
- Load Side Distribution Systems
- Secondary Protection for Light Industrial AC Power

FEATURES

- Meets IEC 1000-4-5 Industry Requirements
- Meets ANSI/IEEE C62.41 Requirements
- Listed to CSA/NRTL, File LR65240-15
- Differential & Common Mode Protection
- Low Clamping Voltage
- Nanosecond Response Time
- Long Life & Maintenance Free
- Each Device 100% Tested

MAXIMUM RATINGS

- Line Voltage: 240 VAC
 - Line Current:
 - 587B062LP: 6.0A
 - 587B102LP: 10.0A
 - 587B162LP: 16.0A
 - 587B302LP: 30.0A**
 - Transient Voltage: 6,000V Peak
 - Transient Current: 3,000A Peak
 - Leakage Current @ 240 VAC:
 - Line-to-Neutral: 1.0mA
 - Line-to-Neutral Voltage: 750V
 - Operating & Storage Temperatures: -40°C to +85°C
- **Product not CSA/NRTL Listed

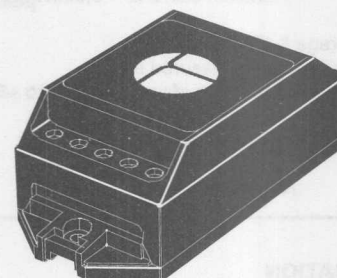
DESCRIPTION

The 587B low profile (LP) series of 240 Volt AC surge suppressors is designed for use by the OEM, the equipment installer and/or maintenance contractor. These modules employ a three-stage, patented, solid state technology which was originally developed for aerospace applications. This multistage TVS technology has proven to be the most cost effective and reliable method in protecting sensitive electronic equipment from over voltage transients.

This device, a unique low clamping voltage transient suppressor, is designed to protect AC powered equipment from the 6,000 Volt peak open circuit voltage and 3,000 Amp short circuit current as defined in ANSI/IEEE C62.41, Category B.

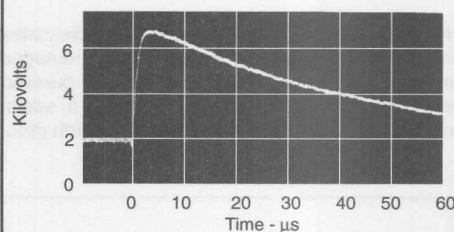
In addition, the 587B low profile series offers a high degree of protection against 240 VAC line noise. It is ideal for protecting 800 Volt rated components because the solid state TVS technology assures that line-to-neutral voltages will not exceed 800 Volts. While the modules are designed for transient voltage protection, the advanced patented circuitry will also attenuate the amplitude and slow the rate of rise of high frequency noise. The 587BxxxLP Modules include common mode and differential mode low-pass filters which are effective in reducing interference from line to equipment and are effective in reducing equipment generated noise to meet FCC, VDE and CSA interference requirements.

IEC 1000-4 COMPATIBLE

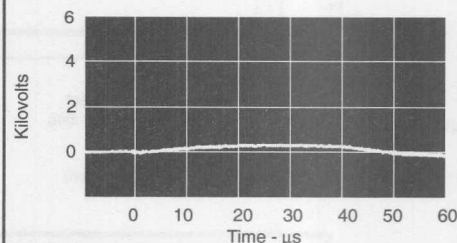


U.S. PATENT 4,563,720

**FIGURE 1
TRANSIENT VOLTAGE THREAT
CONDITION**



**FIGURE 2
TYPICAL CLAMPING ACTION
OF A 16 AMP MODULE**



Figures 1 and 2 are photographs of digitized waveforms showing the typical clamping action of a 16 ampere module. A 12 ohm resistor is used to represent a 10 Amp equipment load. The load is then subjected to the ANSI/IEEE C62.41 Category B test conditions (6,000V/3,000A). These photographs contrast the effect on equipment with and without the protector.

Surgebuster®
Modules

ELECTRICAL CHARACTERISTICS @ 25°C Ambient Temperature

Operating Line Voltage: 240 VAC Max Maximum Line Current: 587B062LP, 6A 587B102LP, 10A 587B162LP, 16A 587B302LP, 30A	RESPONSE TO TRANSIENT VOLTAGES			
	Clamping		Test Condition	
	PROTECTION MODE	MAXIMUM CLAMPING VOLTAGE	OPEN CIRCUIT VOLTAGE @ 1.2 x 50 µs	OPEN CIRCUIT VOLTAGE @ 8 x 20 µs
MAXIMUM RATINGS Transient Voltage: 6,000V ^{peak} Transient Current: 3,000A ^{peak} Storage & Operating Case Temperature (measured at center of mounting surface): -40°C to +85°C Current Leakage at 120 VAC Line to Neutral: 1.0mA Neutral to Ground: N/A	DIFFERENTIAL (Line to Neutral)	800V	6,000V	3,000A
	COMMON (Neutral to Ground) (Line to Ground)	1,000V 1,000V	6,000V 6,000V	3,000A 3,000A

OPERATION

For maximum effectiveness, the protector should be installed directly after the AC line on/off switch and fuse. This will protect the electronics from the AC line switch arcing and the severe transients caused by a fuse clearing.

Some heat is produced when operating at full rated current load, and heat sinking may be required to maintain case temperatures below 85°C. The case temperature is measured at the center of the mounting surface. The unit should not be mounted to a low combusting temperature material such as wood.

High energy transients will cause a large circulating current in the AC input line (2,500A is possible). To prevent electromagnetic coupling, the AC line on the input side of the protector must be dressed away from other wiring and magnetic shielding may be required. In addition, the electrical service must be connected to a low impedance earth ground.

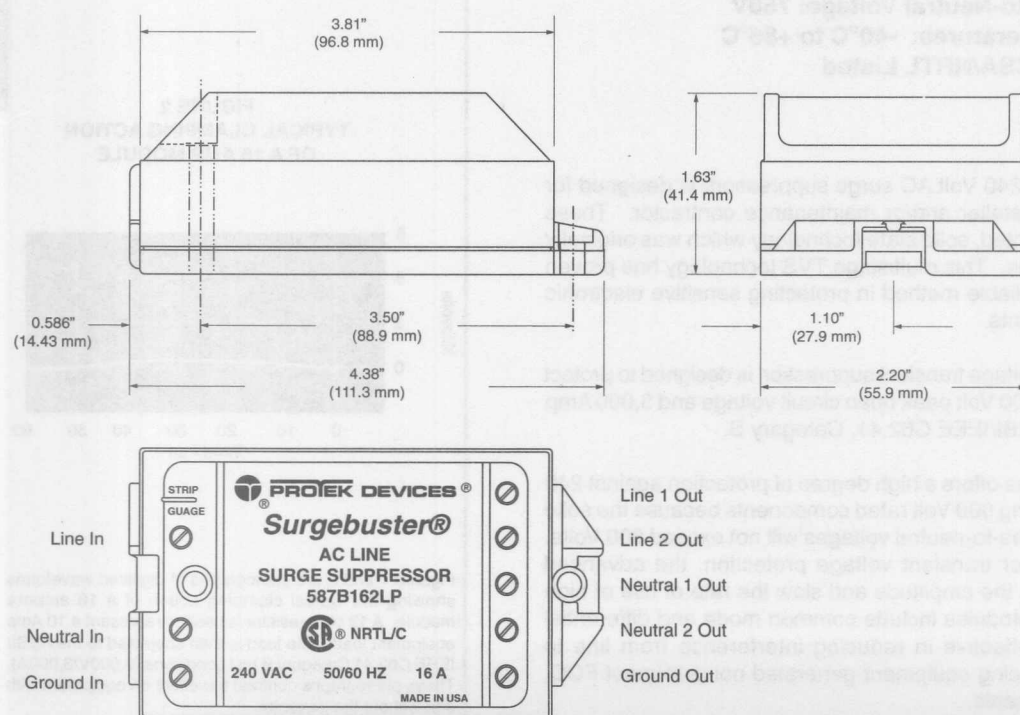
ARRESTER DEFINITIONS

Clamping Voltage: The clamping voltage of an arrester is the voltage that appears across its terminals during conduction of a transient current.

Standard Wave: The waveshape of a surge current or voltage is designated by a combination of two numbers. The first number is for the time of the wave front expressed in microseconds from zero to the peak of the wave. The second number is for the time of the wavetail also expressed in microseconds from zero to the instant that the wavetail reaches one-half of the crest or peak value. Example, 8/20 µs wave.

Transient Current: The transient current of an arrester is the peak surge current which flows through the arrester when voltage clamping occurs.

587BLP DIMENSIONS & CASE OUTLINE



LOW PROFILE 240V AC POWER LINE SURGE SUPPRESSOR

APPLICATIONS

- Hard Wired Equipment AC Power Protection
- Load Side Distribution Systems
- Secondary Protection for Light Industrial AC Power

FEATURES

- Designed for European Market
- Meets IEC 1000-4-5 Industry Requirements
- Meets ANSI/IEEE C62.41 Requirements
- Listed to CSA/NRTL, File LR65240-15
- Differential Mode Protection
- Low Clamping Voltage
- Nanosecond Response Time
- Long Life & Maintenance Free
- Each Device 100% Tested

MAXIMUM RATINGS

- Line Voltage: 240 VAC
 - Line Current:
 - 587B062LPE: 6.0A
 - 587B102LPE: 10.0A
 - 587B162LPE: 16.0A
 - 587B302LPE: 30.0A**
 - Transient Voltage: 6,000V Peak
 - Transient Current: 3,000A Peak
 - Leakage Current @ 240 VAC:
 - Line-to-Neutral: 1.0mA
 - Line-to-Neutral Voltage: 750V
 - Operating & Storage Temperatures: -40°C to +85°C
- **Product not CSA/NRTL Listed

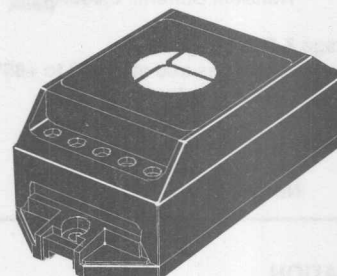
DESCRIPTION

The 587B low profile (LP) series of 240 Volt AC surge suppressors is designed for use by the OEM, the equipment installer and/or maintenance contractor. These modules employ a three-stage, patented, solid state technology which was originally developed for aerospace applications. This multistage TVS technology has proven to be the most cost effective and reliable method in protecting sensitive electronic equipment from over voltage transients.

This device, a unique low clamping voltage transient suppressor, is designed to protect AC powered equipment from the 6,000 Volt peak open circuit voltage and 3,000 Amp short circuit current as defined in ANSI/IEEE C62.41, Category B.

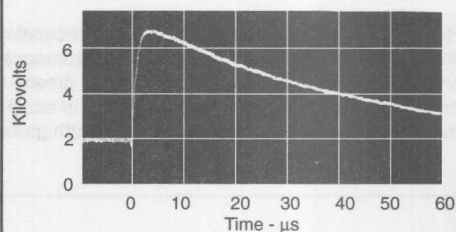
In addition, the 587B low profile series offers a high degree of protection against 240 VAC line noise. It is ideal for protecting 800 Volt rated components because the solid state TVS technology assures that line-to-neutral voltages will not exceed 800 Volts. While the modules are designed for transient voltage protection, the advanced patented circuitry will also attenuate the amplitude and slow the rate of rise of high frequency noise. The 587BxxxLPE Modules include differential mode low-pass filters which are effective in reducing interference from line to equipment and are effective in reducing equipment generated noise to meet FCC, VDE and CSA interference requirements.

IEC 1000-4 COMPATIBLE

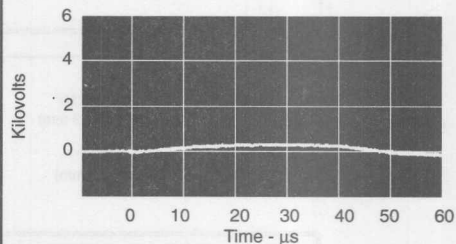


U.S. PATENT 4,563,720

**FIGURE 1
TRANSIENT VOLTAGE THREAT
CONDITION**



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TYPICAL CLAMPING ACTION
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Surgebuster®
Modules

ELECTRICAL CHARACTERISTICS @ 25°C Ambient Temperature

Operating Line Voltage: 240 VAC Max Maximum Line Current: 587B062LPE, 10A 587B102LPE, 16A 587B162LPE, 16A 587B302LPE, 30A	RESPONSE TO TRANSIENT VOLTAGES			
	Clamping		Test Condition	
	PROTECTION MODE	MAXIMUM CLAMPING VOLTAGE	OPEN CIRCUIT VOLTAGE @ 1.2 x 50 μ s	OPEN CIRCUIT VOLTAGE @ 8 x 20 μ s
MAXIMUM RATINGS Transient Voltage: 6,000V_{peak} Transient Current: 3,000A_{peak} Storage & Operating Case Temperature (measured at center of mounting surface): -40°C to +85°C Current Leakage at 240 VAC 1.0mA Line to Neutral: N/A Neutral to Ground:	DIFFERENTIAL (Line to Neutral)	800V	6,000V	3,000A
	COMMON (Neutral to Ground) (Line to Ground)	N/A	N/A	N/A

OPERATION

For maximum effectiveness, the protector should be installed directly after the AC line on/off switch and fuse. This will protect the electronics from the AC line switch arcing and the severe transients caused by a fuse clearing.

Some heat is produced when operating at full rated current load, and heat sinking may be required to maintain case temperatures below 85°C. The case temperature is measured at the center of the mounting surface. The unit should not be mounted to a low combusting temperature material such as wood.

High energy transients will cause a large circulating current in the AC input line (2,500A is possible). To prevent electromagnetic coupling, the AC line on the input side of the protector must be dressed away from other wiring and magnetic shielding may be required. In addition, the electrical service must be connected to a low impedance earth ground.

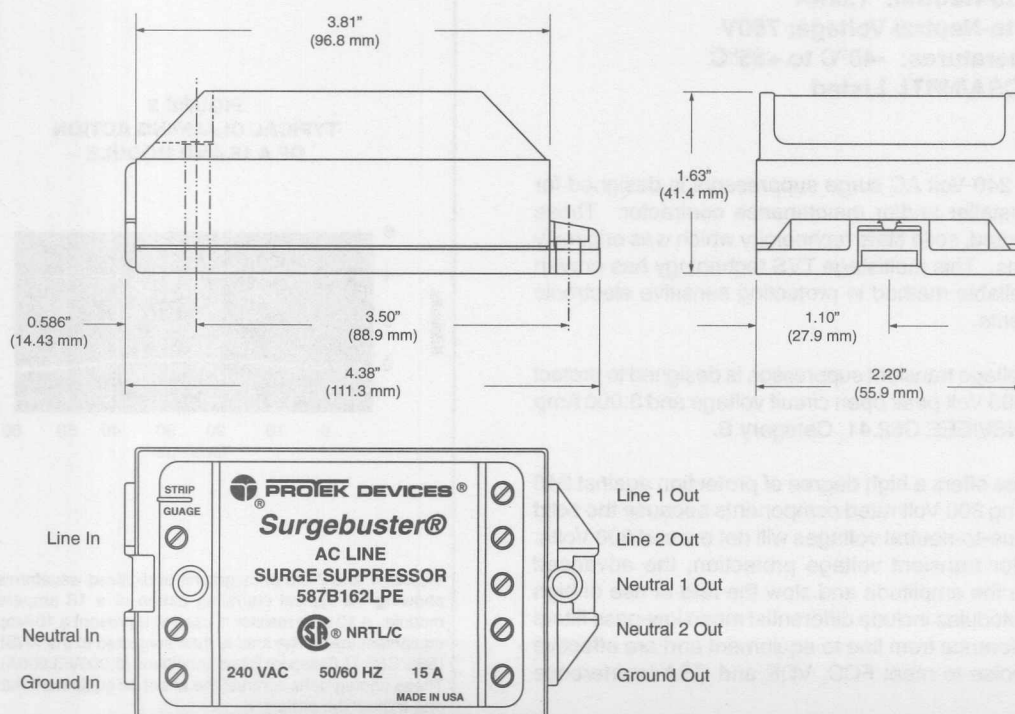
ARRESTER DEFINITIONS

Clamping Voltage: The clamping voltage of an arrester is the voltage that appears across its terminals during conduction of a transient current.

Standard Wave: The waveshape of a surge current or voltage is designated by a combination of two numbers. The first number is for the time of the wave front expressed in microseconds from zero to the peak of the wave. The second number is for the time of the wavetail also expressed in microseconds from zero to the instant that the wavetail reaches one-half of the crest or peak value. Example, 8/20 μ s wave.

Transient Current: The transient current of an arrester is the peak surge current which flows through the arrester when voltage clamping occurs.

587BLPE DIMENSIONS & CASE OUTLINE



COAXIAL LINE PROTECTOR

APPLICATIONS

- Hard Wired Equipment AC Power Protection
- Load Side Distribution Systems
- Primary Protection for Light Industrial AC Power

FEATURES

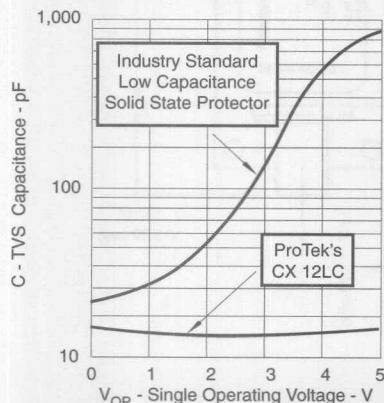
- Low Clamping Voltage
- High Energy Handling
- Provides Protection on High Data Rate LAN Interface Networks
- Permanent Two Stage Protection (Line-to-Ground)
- Automatic Reset - Will Not Interrupt Service
- Nanosecond Response Time
- Each Device 100% Tested
- Two Models Available

DESCRIPTION

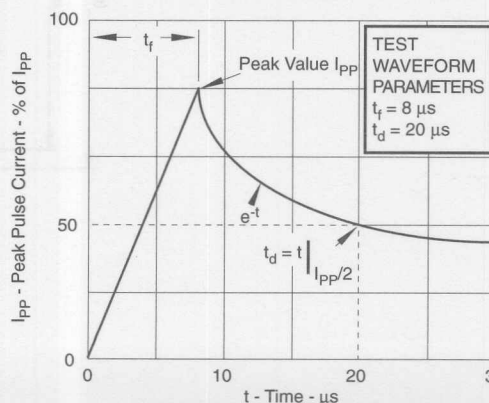
The CX 12 series is a two stage, hybrid surge protector designed to protect interfacing equipment from induced lightning or switching transients. The multistage technique has proven to be the most cost effective and reliable method for protecting sensitive electronic equipment.

Employing state-of-the-art avalanche junction diode technology, these devices provide superior performance for video, Ethernet, Token Ring or other LAN interface systems. They are in-line modules with easy interconnecting terminals. A completely enclosed aluminum housing provides EMC shielding to meet industry standard requirements. The enclosure has two female BNC type connections for easy installation. The case is ground for those installations that require external ground connections.

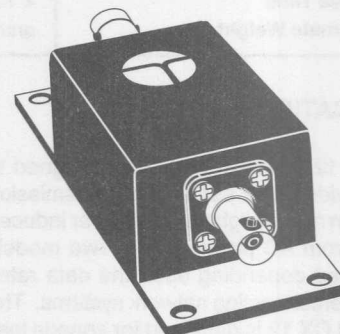
**FIGURE 3
LINEAR VS NON-LINEAR CAPACITANCE**



**FIGURE 4
PULSE WAVE FORM**

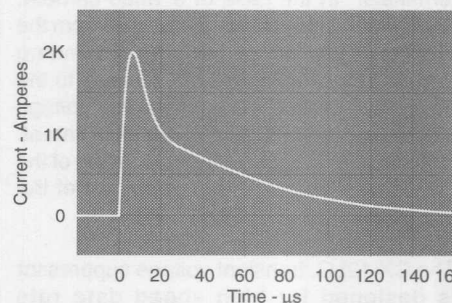


Surgebuster®

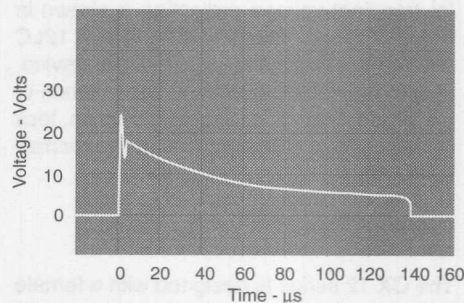


CX 12 PACKAGE

**FIGURE 1
TRANSIENT THREAT**



**FIGURE 2
CX 12LC CLAMPING VOLTAGE**



Figures 1 and 2 are photographs of digitized waveforms showing a typical transient voltage and the clamping action of the CX 12LC module. The device was subjected to a 2,000A, 8/20μs impulse waveform in accordance with ANSI C62.36. The CX 12 has an operating data rate range up to 10MB and the CX 12LC up to 100MB.

MAXIMUM RATINGS @ 25° C		ELECTRICAL CHARACTERISTICS @ 25° C			
Peak Operating Line Voltage (V _{OP})	±12 V	PROTEK PART NUMBER	MAXIMUM CLAMPING VOLTAGE Line-Ground 500A @ 8/20 μ s V _C VOLTS	MAXIMUM LINE THRUPUT RESISTANCE R OHMS	TYPICAL CAPACITANCE C pF @ 0 V, 1 MHz
Operating Line Current (I _O)	200mA				
Maximum Transient Voltage	20kV	CX 12 CX 12LC	24 28	3 10	200 25
Maximum Transient Current	3,000A (8/20 μ s)				
Maximum Leakage Current	5.0 μ A				
Maximum Insertion Loss (10 MHz)	CX 12: 0.5 dB CX 12LC: 0.1 dB				
Operating & Storage Temperature	-40° to +85°C				
Response Time	< 10 ns				
Approximate Weight	grams				

APPLICATION

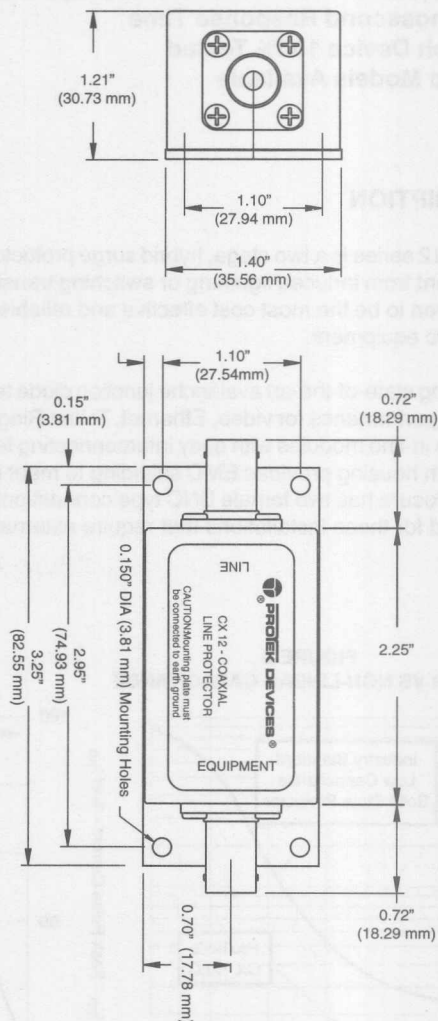
The CX 12 series devices are designed to protect video and serial data transmission lines from nearby lightning strikes or induced surges from AC power lines. Two models are offered depending upon the data rates of the interconnecting network systems. The standard CX 12 is designed for speeds less than 10 MHz and the CX 12LC for speeds greater than 10 MHz. It is necessary to use a video, data or signal line protector along with a power surge protector for service free operation. It is equally important to coordinate both data and power input ground terminals. In the case of a video camera, earth ground may be some distance from the electrical ground or building grounding system. Connecting the CX 12 case to the equipment ground will equalize any voltage differential created by the transient threat. Coordinating the grounding or bonding of the CX 12 is essential for the protection of the equipment.

The CX 12LC, transient voltage suppressor is designed for high speed data rate applications over the operating voltage range of the data line. Coupling capacitors inserted across the data line must be very low to prevent signal distortion or loss of data on the LAN network. Comparison of the two protection products inserted in the data line for transient voltage protection is shown in Figure 3. The bottom line is for the CX 12LC and the top line is for a competitive device. Due to the drastic change in capacitance of the product (top line), signal distortion, loss of data or even access into the computer may be a problem.

INSTALLATION

The CX 12 series is designed with a female BNC type connector on both ends for easy installation. Disconnect the video or data line from the sensitive equipment. Insert the CX 12 in the line near the AC power outlet of the equipment to be protected. Install a cable in between the CX 12 and the equipment to be protected. Attach a ground wire between the case of the CX 12 and the equipment AC power ground.

CX 12 CASE OUTLINE



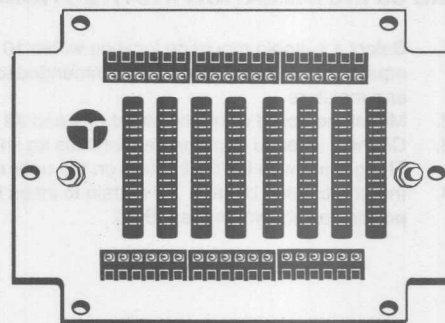
MOTHER BOARD & ENCLOSURE

APPLICATIONS

- Multiple Data Line Panel Protection
- Emergency Shutdown Systems
- Process Control Panels

FEATURES

- MB 80: Glass Filled Laminate Circuit Board with Stand-Offs
- CPE 80: Rugged Cast Aluminum Two-Tone Baked Enamel Base & Removable Cover
- Wiring Interface Accepts a Maximum of Eight (8) Circuit Boards
- Two 10-32 Brass Ground Studs for Low Impedance
- Mother Board is Clearly Marked for Easy Installation



MB 80 MOTHERBOARD

MECHANICAL CHARACTERISTICS

- Screw Type Stripline Connectors for AWG 20-24 Wire
- Four (4) Mounting Holes for #8 Screws
- Approximate Weight MB 80: 340 grams
- Approximate Weight CPE 80: 1.6 kilograms
- Dimensions MB 80: 9"H (22.9 cm) x 5.5"W (14 cm) with 3" (7.6 cm) Minimum Interface Depth if Mounting in an Enclosure
- Dimensions CPE 80: 9.5"H (24.1 cm) x 6.25"W (15.8 cm) with 3.5" (8.9 cm)

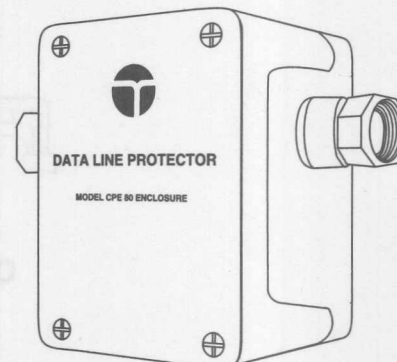
DESCRIPTION

The MB 80 and CPE 80 will accommodate protection of 32 data lines using up to eight (8) SPDs (surge protection device). Each data line SPD has four, two stage protection circuits. The SPDs provide primary and secondary protection against lightning, inductive switching and ESD transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

These interface board assemblies are located between the unprotected transient threat environment (incoming data lines) and the protected sensitive electronic equipment or system. The mother board is marked identifying the protected side. The unprotected side should be located away from the protected data line cables.

The MB 80 is a mother board containing eight (8) edge card connectors and two (2) strip terminal blocks. The edge card connectors are soldered onto the mother board which is connected to the terminal blocks by copper traces. The terminal blocks have screw type connections for easy installation between the unprotected and the protected equipment. Data line surge protection devices are inserted into the edge card connectors for protection of sensitive equipment and/or systems.

The CPE 80 includes a mother board (MB 80) inside a rugged, cast aluminum housing with a removable cover. The housing contains two (2) holes on either side of the case for data line cables. Mounting hardware is provided for the data line cables.



CPE 80 ENCLOSURE

Surgebuster®
Modules

INSTALLATION

Maximum transient protection requires a good grounding system. This consists of a common bonded or ground system which interconnects AC power and data line grounds. A single ground connection is sufficient, however, it is more important that the ground be a low impedance path to the earth. A good earth connection is necessary for lightning transient threat conditions. Connections are usually best using a ground strap where the

cross-sectional area of the ground conductor is maximized. The ground connection is made through the green, AC power ground wire or to a known earth ground system. If a ground wire is used, it is recommended that it is a #14 stranded wire. A low impedance ground is important to minimize a ground voltage potential rise that may cause ground bounce within the system or equipment.

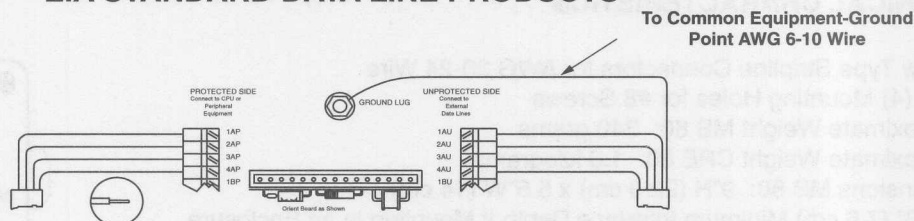
MB 80 INSTALLATION INSTRUCTIONS

1. Select a suitable mounting location within 10 meters of the protected equipment. An enclosure is recommended to protect against dust and moisture.
2. Mount the board using the stand-offs and #8 screws provided.
3. Connect wires to appropriate terminals as shown in Figures 1 and 2. The ground wire **MUST** be kept on the unprotected side of the board.
4. Insert protected boards. Be certain to insert boards in the correct position as shown on the MB 80.

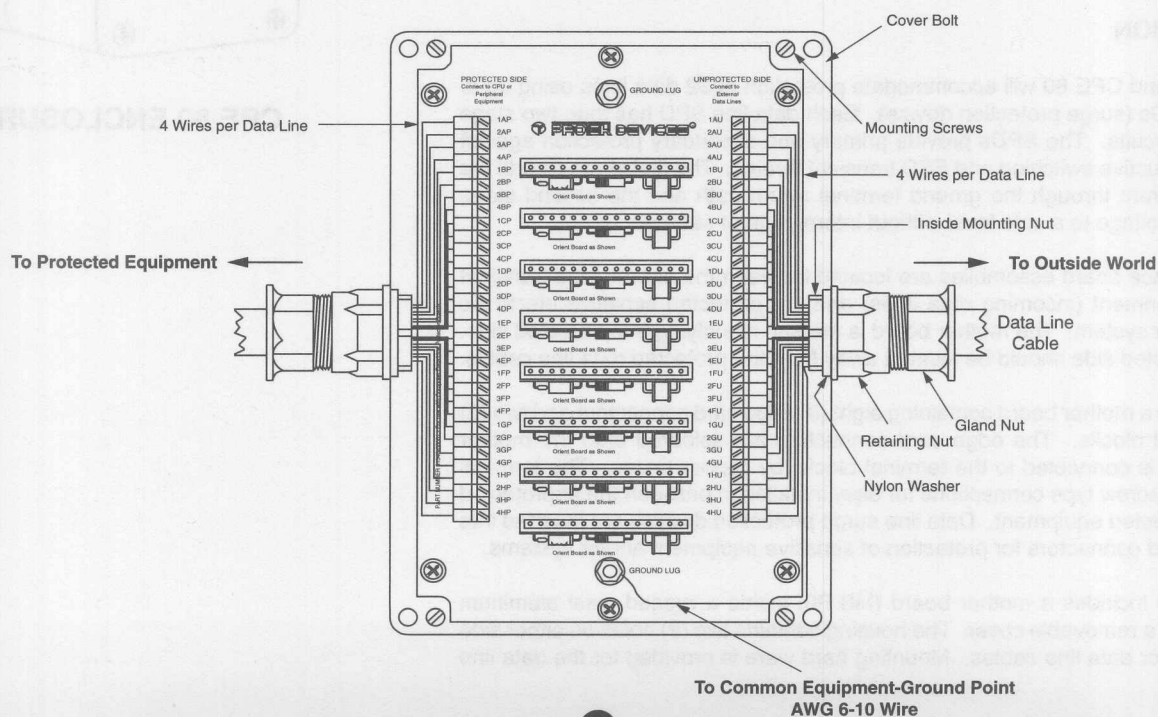
CPE 80 INSTALLATION INSTRUCTIONS

1. Select a suitable mounting location within 10 meters of the protected equipment.
2. Remove the cover and install cable retainer assembly in holes. Do not tighten gland nut bushing. See cable retainer assembly detail in Figure 1.
3. Install base on a flat surface using #8 screws provided.
4. Insert wires through cable retainer assemblies and connect to appropriate terminals as shown in Figures 1 and 2. The ground wire **MUST** enter the enclosure **ONLY** through the unprotected side.
5. After completion of wiring, hand tighten gland nut bushing.
6. Insert protector boards. Be certain to insert boards in the correct position as shown on the printed circuit board.
7. Replace cover and tighten cover mounting screws.

TYPICAL WIRING FORMAT FOR ONE 4 WIRE RS EIA STANDARD DATA LINE PRODUCTS



CPE & MB 80 WIRING CONFIGURATION



PBX LOW VOLTAGE TELEPHONE PROTECTOR

APPLICATIONS

- **Telcom Terminal Equipment**
- **Data/Telcom Interfaces**
- **Dedicated Fax & Modem Machines**

FEATURES

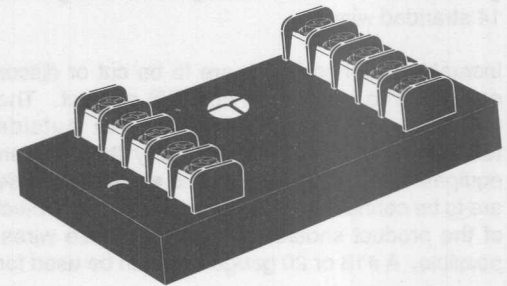
- **Meets IEC 1000-4-5, Level 4 & 5 Requirements**
- **Designed for 50 Volt Telephone Lines**
- **Automatic Reset - Will Not Interrupt Service**
- **Permanent Two-Stage Protection**
- **4 Wire, Line-to-Ground Protection**
- **Subnanosecond Response Time**
- **Effective Against Lightning, Inductive Switching & ESD**

DESCRIPTION

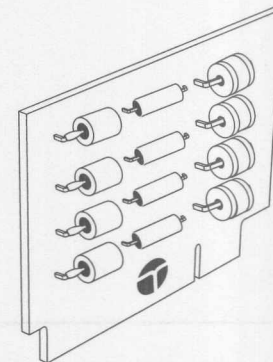
The TEL50E/B is a two-stage transient voltage protector providing primary and secondary protection against lightning, inductive switching and electrostatic discharge (ESD) transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

The TEL50E/B is designed to protect telecom lines from common mode (line-to-ground) transients. There are four (4) independent lines referenced to the ground terminals

This product can also be used for the protection of Key Service Units (KSU) and handset stations. For most applications, the product should be located as close as possible to the equipment being protected. A low impedance grounding system is important to maintain a low clamping voltage between the line-to-ground connection. Single point grounding is recommended.



TEL50E PACKAGE



TEL50B PACKAGE

Surgebuster®
Modules

MAXIMUM RATINGS @ 25° C		ELECTRICAL CHARACTERISTICS @ 25° C			
Peak Operating Line Voltage (V_{OP})	±50V	MAXIMUM CLAMPING VOLTAGE (8/20μs) @ 500A V_C VOLTS	MAXIMUM LINE THRUPUT RESISTANCE R OHMS	MAXIMUM LEAKAGE CURRENT @ 50 V_{OP} I_D μA	MAXIMUM CAPACITANCE @ 0 V, 1 MHz C pF
Operating Line Current (I_O)	200mA	95	12	5	800
Maximum Transient Voltage	10kV				
Maximum Transient Current (8/20μs waveshape)	10kA/ Wire 40kA/ Protector				
Operating & Storage Temperature	-55° to +100°C				
Response Time	< 1 nanosecond				
Approximate Weight	TEL50E: 142 grams TEL50B: 28 grams				

There are five (5) terminals on both the **line** and **equipment** side of the TEL50E, four telecom line terminals and one ground terminal. Both ground terminals, shown on the label, are connected internally. A single ground connection is sufficient, however, it is recommended that both ground connections be used for a lower impedance path to earth. This connection can be made through the green, AC power ground wire or a known earth ground. The ground wire should be # 14 stranded wire.

Incoming telephone lines are to be cut or disconnected from the equipment to insert the TEL50E/B product. The **line** side of the terminals are to be connected to outside telephone or telecommunication lines that carry the transient threat into the equipment to be protected. The **equipment** side of the terminals are to be connected to the equipment to be protected. The location of the product should be such that these wires are as short as possible. A #18 or 20 gauge wire can be used for this connection.

The TEL50B requires an edge connector interface for installation. A standard 15 position edge connector can be used. When mounting

or wiring the connectors onto a printed circuit board, be sure that the correct terminals are soldered. The **line** side of the board connections are finger contacts 12 thru 15. The **equipment** side of the board connections are finger contacts 2 thru 5. The boards are conformal coated for limited protection against moisture.

ProTek's data line protector is designed with a short circuit failure mode to give maximum protection. A fuse, PTC, fusable link, or circuit breaker is recommended for each data/signal line on the input (line) side of the protector for those applications that require an open circuit failure mode.

Caution: A low DC resistance ground may not be indicative of a good lightning ground. Lightning contains a broad spectrum of frequencies up to 1 MHz. A low impedance path to ground at the transient frequencies is necessary. A ground strap is recommended or a #6 AWG stranded wire. For wire lengths over 1.5 meters, there may be some excessive line to earth potential under severe thunderstorm conditions.

Technical drawing of the PRO-1000 terminal block, showing top and side views with dimensions.

Top View Dimensions:

- Overall Width: 3.8" MAX (95.5 mm)
- Internal Width: 3.25" ± 0.015" (82.6 mm ± 0.38 mm)
- Overall Height: 2.25" MAX (57.2 mm)
- Mounting Hole Diameter: 1.125" (30.2 mm)

Top View Labels:

- Adhesive Mylar Label
- Terminal Screw
- Mounting Hole for #8 Screw

Top View Details:

- Label Text: "PRO-1000", "EQUIPMENT", "LINE", "NO.", "1", "2", "3", "4", "5", "6", "7", "8", "9", "10", "11", "12", "13", "14", "15", "16", "17", "18", "19", "20", "21", "22", "23", "24", "25", "26", "27", "28", "29", "30", "31", "32", "33", "34", "35", "36", "37", "38", "39", "40", "41", "42", "43", "44", "45", "46", "47", "48", "49", "50", "51", "52", "53", "54", "55", "56", "57", "58", "59", "60", "61", "62", "63", "64", "65", "66", "67", "68", "69", "70", "71", "72", "73", "74", "75", "76", "77", "78", "79", "80", "81", "82", "83", "84", "85", "86", "87", "88", "89", "90", "91", "92", "93", "94", "95", "96", "97", "98", "99", "100", "101", "102", "103", "104", "105", "106", "107", "108", "109", "110", "111", "112", "113", "114", "115", "116", "117", "118", "119", "120", "121", "122", "123", "124", "125", "126", "127", "128", "129", "130", "131", "132", "133", "134", "135", "136", "137", "138", "139", "140", "141", "142", "143", "144", "145", "146", "147", "148", "149", "150", 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The diagram illustrates the connector assembly with three views:

- Top View:** Shows the connector footprint on the PCB. Dimensions include a maximum width of 3.0" (76.2 mm) and a maximum height of 0.50" (12.7 mm) for the central component.
- Side View:** Shows the profile of the connector. Dimensions include a maximum height of 1.90" (48.2 mm) and a maximum width of 0.30" (7.6 mm) for the base.
- Continuity View:** A table showing the mapping between input and output pins.

CONTINUITY	
INPUT	OUTPUT
12	5
13	4
14	3
15	2

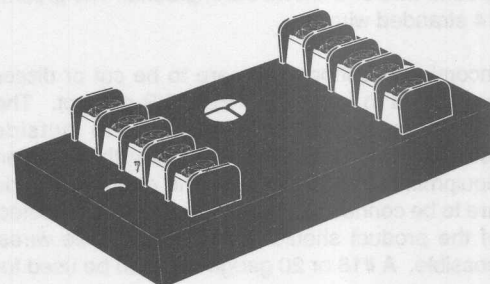
Note: I/O contacts spaced at 0.156" (3.96 mm) centers.

Note: I/O contacts spaced at 0.156" (3.96 mm) centers

TELEPHONE INTERFACE PROTECTOR

APPLICATIONS

- Telcom Equipment Connected to Telcom Lines
- Line Connected Modems & Fax Machines
- Remote Telephone Extensions
- Private Wire/Leased Phone Lines



TEL185E PACKAGE

FEATURES

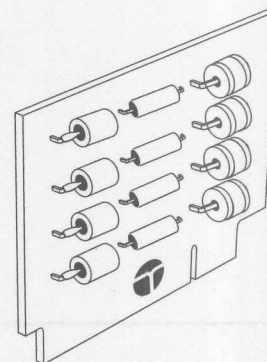
- Meets IEC 1000-4-5, Level 4 & 5 Requirements
- Designed for 185 Volt Telephone Lines
- Automatic Reset - Will Not Interrupt Service
- Permanent Two-Stage Protection
- 4 Wire, Line-to-Ground Protection
- Subnanosecond Response Time
- Effective Against Lightning, Inductive Switching & ESD

DESCRIPTION

The TEL185E/B is a two-stage transient voltage protector providing primary and secondary protection against lightning, inductive switching and electrostatic discharge (ESD) transient threats. The first stage diverts the transient current through the ground terminal return path and the second stage clamps the voltage to a safe level without interruption of service.

The TEL185E/B is designed to protect telecom lines from common mode (line-to-ground) transients. There are four (4) independent lines referenced to the ground terminals

This product can also be used for the protection of Key Service Units (KSU) and handset stations. For most applications, the product should be located as close as possible to the equipment being protected. A low impedance grounding system is important to maintain a low clamping voltage between the line-to-ground connection. Single point grounding is recommended.



TEL185B PACKAGE

Surgebuster®
Modules

MAXIMUM RATINGS @ 25° C		ELECTRICAL CHARACTERISTICS @ 25° C			
Peak Operating Line Voltage (V_{OP})	±185V	MAXIMUM CLAMPING VOLTAGE (8/20μs) @ 500A V_C VOLTS	MAXIMUM LINE THRUPUT RESISTANCE R OHMS	MAXIMUM LEAKAGE CURRENT @ 185 V_{OP} I_D μA	MAXIMUM CAPACITANCE @ 0 V, 1 MHz C pF
Operating Line Current (I_O)	200mA	330	12	5	300
Maximum Transient Voltage	20kV				
Maximum Transient Current (8/20μs waveshape)	10kA/ Wire 40kA/ Protector				
Operating & Storage Temperature	-55° to +100°C				
Response Time	< 1 nanosecond				
Approximate Weight	TEL185E: 142 grams TEL185B: 28 grams				

INSTALLATION INSTRUCTIONS

There are five (5) terminals on both the **line** and **equipment** side of the TEL50E, four telecom line terminals and one ground terminal. Both ground terminals, shown on the label, are connected internally. A single ground connection is sufficient, however, it is recommended that both ground connections be used for a lower impedance path to earth. This connection can be made through the green, AC power ground wire or a known earth ground. The ground wire should be # 14 stranded wire.

Incoming telephone lines are to be cut or disconnected from the equipment to insert the TEL50E/B product. The **line** side of the terminals are to be connected to outside telephone or telecommunication lines that carry the transient threat into the equipment to be protected. The **equipment** side of the terminals are to be connected to the equipment to be protected. The location of the product should be such that these wires are as short as possible. A #18 or 20 gauge wire can be used for this connection.

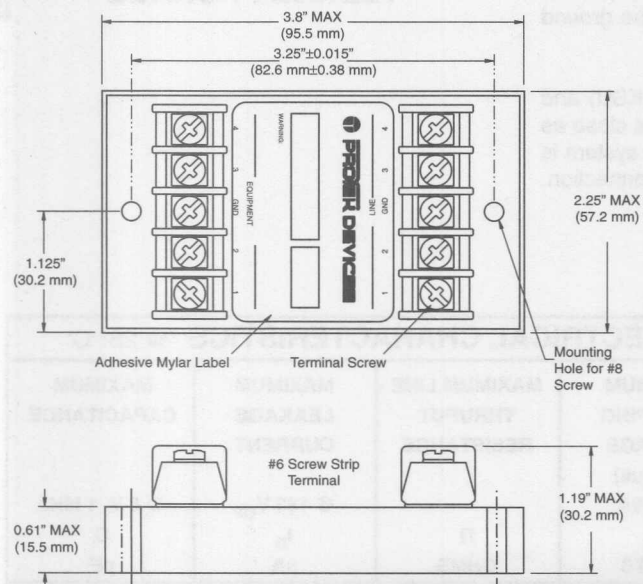
The TEL50B requires an edge connector interface for installation. A standard 15 position edge connector can be used. When mounting

or wiring the connectors onto a printed circuit board, be sure that the correct terminals are soldered. The **line** side of the board connections are finger contacts 12 thru 15. The **equipment** side of the board connections are finger contacts 2 thru 5. The boards are conformal coated for limited protection against moisture.

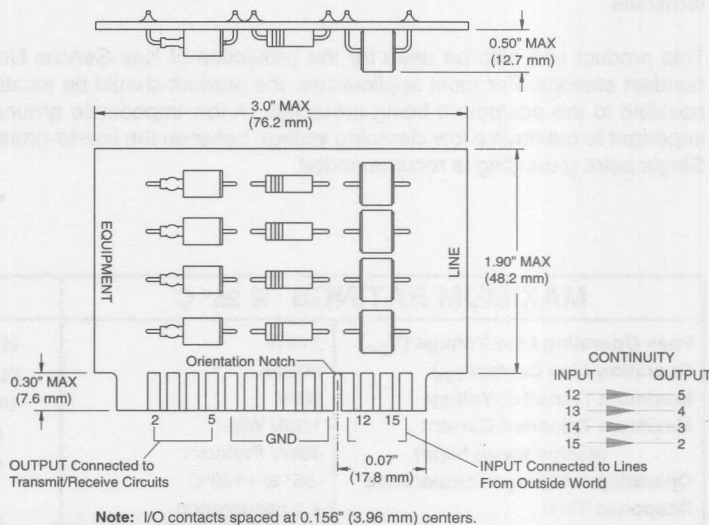
ProTek's data line protector is designed with a short circuit failure mode to give maximum protection. A fuse, PTC, fusable link, or circuit breaker is recommended for each data/signal line on the input (line) side of the protector for those applications that require an open circuit failure mode.

Caution: A low DC resistance ground may not be indicative of a good lightning ground. Lightning contains a broad spectrum of frequencies up to 1 MHz. A low impedance path to ground at the transient frequencies is necessary. A ground strap is recommended or a #6 AWG stranded wire. For wire lengths over 1.5 meters, there may be some excessive line to earth potential under severe thunderstorm conditions.

TEL185E CASE OUTLINE



TEL185B BOARD OUTLINE



Note: I/O contacts spaced at 0.156" (3.96 mm) centers.

SECTION 7

Quality Assurance

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SPECIFICATIONS: ProTek reserves the right to change the electrical and or mechanical characteristics described herein without notice (except JEDEC).

DESIGN CHANGES: ProTek reserves the right to discontinue product lines without notice, and that the final judgement concerning selection and specifications is the buyer's and that in furnishing engineering and technical assistance, ProTek assumes no responsibility with respect to the selection or specifications of such products.

CORPORATE PHILOSOPHY

ProTek Devices is totally dedicated to manufacturing products which meet all specified and implied standards of performance, quality and reliability. Our Manufacturing and Quality Control Systems have been designed to support this philosophy.

QUALITY ASSURANCE SYSTEMS

As a supplier, our Quality Assurance Systems conform to the requirements of the following specifications:

MIL-I-45208A
MIL-PRF-19500
MIL-STD-45662A
MIL-STD-750
MIL-STD-105

ENVIRONMENTAL TEST CAPABILITIES

<u>Test/Operation</u>	<u>MIL-STD-750 Test Method</u>
Bond Strength	2037
Burn-in/HRTB	1038
Constant Acceleration	2006
Decap/Design Verification	
Destructive Physical Analysis	
Dielectric Strength	
Electric Test @ Min/Max Rated Temperatures	
Hermeticity (Fine & Gross Leak)	1071H/D
Highly Accelerated Stress Test	
Insulation Resistance	1016
Moisture Resistance	1021
Non Operating Life	1031/1032
Particle Impact Noise Protection	2052
Salt Atmosphere	1041
Shock	2016
Solderability	2026
Stabilization Bake	1032
Steady-State Operation Life	1026/1027
Surge (Repetitive)	
Temperature Cycling	1051
Terminal Strength	2036
Thermal Shock	1056
Vibration, variable frequency	2056
X-Ray	2076



STATISTICAL RELIABILITY SAMPLING PROGRAM

ProTek Devices is committed to the continuous quality improvement of our products through the monitoring of production lots. A sampling program provides the vehicle to monitor each product series to accumulate reliability data on a family of devices. Products are randomly pulled from production lots for reliability testing. Electrical tests are conducted on each device selected according to their data sheet specified test conditions. A failure is defined as those devices that fail to meet the specified product data sheet limits or exhibit a significant parameter shift.

Our accumulative product data information reports are updated monthly for those products selected for testing. This report is also designed to aid in the qualification and characterizations of new products. Additional tests are added for qualification (see example). A copy of the qualification report and the accumulative reliability report is available for distribution by contacting the factory.

Refer to pages 7-4 and 7-5 for sample test plan documents.

QUALIFICATION SUMMARY DATA

Product Data Information

ENVIRONMENTAL TEST	STRESS CONDITIONS	ACCUMULATED NO. OF DEVICES	DEVICE HRS OR DEVICE CYCLES	NUMBER OF FAILURES*
Temperature Cycling	-55° C to +150° C 100 Cycles			
High Temperature Storage	T _A = + 150° C t = 1,000 hrs			
High Temperature Reverse Bias	Rev. Bias = Rated V _{WM} t = 1,000 hrs			
Pressure Cooker (Autoclave)	JEDEC Std. #22 Method A-102B 15 psig, 100% RH			
Repetitive Surge	@ rated I _{PP} = 100 Cycles			
X-Ray	MIL-STD-750 Method 2076			
Solderability	MIL-STD-750 Method 2026			
Resistance to Solvents	MIL-STD-750 Method 1022			
Group A Electricals	Per Product Data Sheet			

Note: Sample form for qualification testing of new products.

*Failure Definitions: Exceeds published electrical specification limits.



RELIABILITY SUMMARY DATA **Accumulative Product Data Information Product Series**

ENVIRONMENTAL TEST	STRESS CONDITIONS	ACCUMULATED NO. OF DEVICES	DEVICE HRS OR DEVICE CYCLES	NO. OF FAILURES *
Temperature Cycling	-55° C to +150° C 100 Cycles			
High Temperature Storage	T _A = +150° C t = 1,000 hrs			
High Temperature Reverse Bias	Rev. Bias = Rated V _{WM} t = 1,000 hrs			
Pressure Cooker (Autoclave)	JEDEC Std. #22 Method A-102B 15 psig, 100% RH			
Repetitive Surge	@ rated I _{PP}			

Note: Ongoing reliability test plan for major series product lines. Devices pulled periodically from production by quality control for reliability testing.

*Failure Definitions: Exceeds Published Electrical Specification Limits.

SUBMODULE SCREENING TEST PLAN **For Modules H1, H2, and H3**

<u>TEST</u>	<u>CONDITION</u>	<u>MIL-STD-750 TEST METHOD</u>
Storage	$T_A = +175^{\circ}\text{C}$ for 24 hours	1032
Temp Cycle	-65°C to $+175^{\circ}\text{C}$, 20 cycles, 15 minutes each extreme	1051
Acceleration	20KG, Y1 axis, no hold time	2006
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
Pulse	20 pulses @ rated I_{PP} , $t_p = 10 \times 1000 \mu\text{s}$	
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
Burn-In	$T_A = +125^{\circ}\text{C}$ @ rated V_{WM} for 96 hours	1038
Electrical	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 50\%$ or $1 \mu\text{A}$, whichever is greater	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 2\%$ from initial reading	4022
Fine Leak	$5 \times 10^{-8} \text{ atmcc/sec}$	1071G/H
Gross Leak	$T_A = +125^{\circ}\text{C}$ for 1 min, no bubbles	1071C/D
Group A	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
	Clamping Voltage (V_C) @ I_{PP} , $t_p = 10 \times 1000 \mu\text{s}$	
	Forward Voltage (V_f) @ I_f , $t_p = 8.3 \text{ ms}$	4011

Note: For bidirectional devices test both polarities-split hours on Burn-in test and surge pulses to 50% each polarity.



MODULE SCREENING TEST PLAN **For Module H1**

<u>TEST</u>	<u>CONDITION</u>	<u>MIL-STD-750 TEST METHOD</u>
Group A	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage (V_{BR}) @ I_T	4022
	Clamping Voltage (V_C) @ I_{PP} , t_p = Rated	
	Forward Voltage (V_f) @ I_f , t_p = 8.3 ms	4011

Attributes Data Supplied
Module - H1

MODULE SCREENING TEST PLAN **For Module H2**

<u>TEST</u>	<u>CONDITION</u>	<u>MIL-STD-750 TEST METHOD</u>
Storage	$T_A = +150^\circ\text{C}$ for 24 hours	1032
Temp Cycle	-65°C to $+150^\circ\text{C}$, 10 cycles, 30 minutes each extreme	1051
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage (V_{BR}) @ I_T	4022
Pulse	20 pulses @ rated I_{PP} , t_p = rated	
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
Burn-In	$T_A = +125^\circ\text{C}$ @ rated V_{WM} for 96 hours	1038
Electrical	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 50\%$ or $1\ \mu\text{A}$, whichever is greater	4016
	Breakdown Voltage (V_{BR}) @ I_T , $D-V_{(BR)} = \pm 2\%$ from initial reading	4022
Group A	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage (V_{BR}) @ I_T	4022
	Clamping Voltage (V_C) @ I_{PP} , t_p = rated	
	Forward Voltage (V_f) @ I_f , t_p = 8.3 ms	4011

Note: For bidirectional devices test both polarities-split hours on Burn-in test and surge pulses to 50% each polarity.

Attributes Data Supplies
Module - H2

Quality
Assurance

MODULE GROUP B TESTING **For Module H3**

TEST	CONDITION	MIL-STD-750 TEST METHOD
SUBGROUP 1		
Solderability		2026
Resistance to Solvents		1022
SUBGROUP 2		
Temp Cycle	-65°C to +150°C, 10 cycles, 30 minutes each extreme	1051
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
SUBGROUP 3		
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
Operating Life	@ rated V_{WM} , $T_A = +125^\circ\text{C}$ for 340 hours	1026
Electrical	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 50\%$ or $1\ \mu\text{A}$, whichever is greater	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 5\%$ from initial reading	4022

Note: For bidirectional devices test both polarities-split hours on Operating Life to 50% each polarity.



MODULE GROUP C TESTING **For Module H3**

TEST	CONDITION	MIL-STD-750 TEST METHOD
<u>SUBGROUP 1</u>		
Physical Dimensions		2066
<u>SUBGROUP 2</u>		
Terminal Strength (tension)	Test condition A, W = 10lbs., t = 15 seconds	2036
Moisture Resistance	Omit initial conditioning	1021
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
<u>SUBGROUP 3</u>		
Shock	1,500G's, 0.5ms, 5 blows in each orientation X1, Y1, Z1	2016
Vibration, Var. Freq.		2056
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
<u>SUBGROUP 4</u>		
Salt Atmosphere		1041
<u>SUBGROUP 5</u>		
Operating Life	@ rated V_{WM} , $T_A = +125^\circ\text{C}$ for 1,000 hours	1026
Electrical	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 50\%$ or $1\ \mu\text{A}$, whichever is greater	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 5\%$ from initial reading	4022

Note: For bidirectional devices test both polarities-split hours on Operating Life to 50% each polarity.

Attributes Data Supplied
Sampling per MIL-PRF-19500
Module - H3 (Group C)

MIL PROCESSING TEST PLAN FOR DLZ SERIES - H1 VERSIONS
(Unidirectional)

<u>TEST</u>	<u>CONDITION</u>	<u>MIL-STD-750 TEST METHOD</u>
Internal Visual		2072
Storage	$T_A = +150^{\circ}\text{C}$ for 24 hours	1032
Temp Cycle	10 cycles, 15 minutes each extreme @ min/max rated temps	1051
Acceleration	20KG, Y1 axis, no hold time	2006
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
Pulse	20 pulses @ $I_{PP} = 10\text{A}$, $t_p = 8 \times 20 \mu\text{s}$	
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016
Burn-In (HTRB)	$T_A = +125^{\circ}\text{C}$ @ rated V_{WM} for 160 hours	1038
Electrical	Reverse Current (I_R) @ rated V_{WM} , $D-I_R=100\%$ or 20% of Group A limit, whichever is greater	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 2\%$ from initial reading	4022
Fine Leak	1×10^{-8} atmcc/sec	1071G/H
Gross Leak	$T_A = +125^{\circ}\text{C}$, no bubbles	1071C/D
Marking		
Group A	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
	Clamping Voltage (V_C) @ I_{PP} , $t_p = 8 \times 20 \mu\text{s}$	
	Capacitance @ 0V	4001



MIL PROCESSING GROUP B TEST PLAN FOR DLZ SERIES - H2 VERSIONS (Unidirectional)

TEST	CONDITION	MIL-STD-750 TEST METHOD	SAMPLE PLAN (LTPD)
<u>SUBGROUP 1</u>			15
Solderability		2026	
Resistance to Solvents		1022	
<u>SUBGROUP 2</u>			10
Temp Cycle	10 cycles, 15 minutes @ min/max rated temperatures	1051	
Fine Leak	1×10^{-8} atmcc/sec	1071G/H	
Gross Leak	$T_A = +125^\circ\text{C}$, no bubbles	1071D	
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016	
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022	
<u>SUBGROUP 3</u>			5
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016	
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022	
Pulse	20 pulses @ $I_{PP} = 10\text{A}$, $t_p = 8 \times 20 \mu\text{s}$		
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016	
Steady State Op-Life (HTRB)	$T_A = +125^\circ\text{C}$ @ rated V_{WM} for 340 hours	1027	
Electrical	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 100\%$ or 20% of Grp A Limit, whichever is >	4016	
	Breakdown Voltage ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 5\%$ from initial reading	4022	
<u>SUBGROUP 4</u>			
Decap, Internal Visual	Design verification, 1 device	2075	
Bond Strength	11 wires	2037	
<u>SUBGROUP 5</u>	Not applicable		
<u>SUBGROUP 6</u>			7
Electrical	Reverse Current (I_R) @ rated V_{WM}	4016	
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022	
High Temperature Life (non-op)	$T_{stg} = +150^\circ\text{C}$ for 340 hours	1032	
Electrical	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 100\%$ or 20% of Grp A Limit, whichever is >	4016	
	Breakdown Voltage ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 5\%$ from initial reading	4022	

Attributes Data Supplied
Sampling per MIL-PRF-19500, DLZ - H2 Group B (Unidirectional)

MIL PROCESSING TEST PLAN FOR DLZ SERIES-H1 VERSIONS
(Bidirectional)

TEST	CONDITION	MIL-STD-750 TEST METHOD
Internal Visual		2072
Storage	$T_A = +150^{\circ}\text{C}$ for 24 hours	1032
Temp Cycle	10 cycles, 15 minutes each extreme @ min/max rated temps	1051
Acceleration	20KG, Y1 axis, no hold time	2006
Electrical (Polarities A & B)	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
Pulse	10 pulses each polarity @ $I_{PP} = 10\text{A}$, $t_p = 8 \times 20 \mu\text{s}$	
Electrical	Reverse Current (I_R) @ rated V_{WM} (Polarities A & B)	4016
Burn-In (HTRB)	$T_A = +125^{\circ}\text{C}$ @ rated V_{WM} for 80 hours (Polarity A)	1038
Electrical (Polarity A)	Reverse Current (I_R) @ rated V_{WM} , $D-I_R=100\%$ or 20% of Group A limit, whichever is greater	4016
Burn-In (HTRB)	$T_A = +125^{\circ}\text{C}$ @ rated V_{WM} for 80 hours (Polarity B)	1038
Electrical	Reverse Current (I_R) @ rated V_{WM} , $D-I_R=100\%$ or 20% of Group A limit, whichever is greater (Polarity B)	4016
	Breakdown Volt. ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 2\%$ from initial reading (Polarity A & B)	4022
	Reverse Current (I_R) @ rated V_{WM} (Polarity A)	4016
Fine Leak	1×10^{-8} atmcc/sec	1071G/H
Gross Leak	$T_A = +125^{\circ}\text{C}$, no bubbles	1071C/D
Marking		
Group A	Reverse Current (I_R) @ rated V_{WM}	4016
	Breakdown Voltage ($V_{(BR)}$) @ I_T	4022
	Clamping Voltage (V_C) @ I_{PP} , $t_p = 8 \times 20 \mu\text{s}$	
	Capacitance @ 0 V	4001



**MIL PROCESSING GROUP B TEST PLAN FOR DLZ SERIES-H2 VERSIONS
(Bidirectional)**

<u>TEST</u>	<u>CONDITION</u>	<u>MIL-STD-750 TEST METHOD</u>	<u>SAMPLE PLAN (LTPD)</u>
<u>SUBGROUP 1</u>			15
Solderability		2026	
Resistance to Solvents		1022	
<u>SUBGROUP 2</u>			10
Temp Cycle	10 cycles, 15 minutes @ min/max rated temperatures	1051	
Fine Leak	1×10^{-8} atmcc/sec	1071G/H	
Gross Leak	$T_A = +125^\circ\text{C}$, no bubbles	1071D	
Electrical (Polarities A & B)	Reverse Current (I_R) @ rated V_{WM} Breakdown Voltage ($V_{(BR)}$) @ I_T	4016 4022	
<u>SUBGROUP 3</u>			5
Electrical (Polarities A & B)	Reverse Current (I_R) @ rated V_{WM} Breakdown Voltage ($V_{(BR)}$) @ I_T	4016 4022	
Pulse	10 pulses @ $I_{PP} = 10\text{A}$, $t_p = 8 \times 20 \mu\text{s}$		
Electrical	Reverse Current (I_R) @ rated V_{WM} (Polarities A & B)	4016	
Steady State Op-Life (HTRB)	$T_A = +125^\circ\text{C}$ @ rated V_{WM} for 170 hours (Polarity A)	1027	
Electrical (Polarity A)	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 100\%$ or 20% of Grp. A Limit, whichever is >	4016 4022	
Steady State Op-Life (HTRB)	$T_A = +125^\circ\text{C}$ @ rated V_{WM} for 170 hours (Polarity B)	1027	
Electrical (Polarity B) (Polarities A & B)	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 100\%$ or 20% of Grp. A Limit, whichever is > Breakdown Voltage ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 5\%$ from initial reading Reverse Current (I_R) @ rated V_{WM} (Polarity A)	4016 4022 4016	
<u>SUBGROUP 4</u>			
Decap, Internal Visual	Design verification, 1 device	2075	
Bond Strength	11 wires	2037	
<u>SUBGROUP 5</u>	Not applicable		
<u>SUBGROUP 6</u>			7
Electrical (Polarities A & B)	Reverse Current (I_R) @ rated V_{WM} Breakdown Voltage ($V_{(BR)}$) @ I_T	4016 4022	
High Temperature Life (non-op)	Tstg = $+150^\circ\text{C}$ for 340 hours	1032	
Electrical (Polarities A & B)	Reverse Current (I_R) @ rated V_{WM} , $D-I_R = 100\%$ or 20% of Grp. A Limit, whichever is > Breakdown Voltage ($V_{(BR)}$) @ I_T , $D-V_{(BR)} = \pm 5\%$ from initial reading	4016 4022	

MIL PROCESSING GROUP B TEST PLAN FOR DLE SERIES-H2 VERSIONS
(Bidirectional)

TEST	CONDITION	TEST METHOD	SAMPLE PLAN (LTPD)
SUBGROUP 1	Reliability	2026	10
	Procedures to Generate	1025	
SUBGROUP 2	Temp Cycle	70 cycles, 15 minutes @ maximum rated temperature	70
	Power Loss	1 x 10" ampere	
	Ground Test	$T_A = +125^\circ\text{C}$ no bias	
	Electrical (Procedures A & B)	Reverse Current (I_{RC}) @ rated V_{RR} Breakdown Voltage (V_{BR}) @ I_{BR}	
		4016 4022	
SUBGROUP 3	Electrical (Procedures A & B)	Reverse Current (I_{RC}) @ rated V_{RR} Breakdown Voltage (V_{BR}) @ I_{BR}	3
	Power	4016 4022	
	Electrical	4016 4022	
	Steady State Output (HTRP)	Reverse Current (I_{RC}) @ rated V_{RR} for 170 hours (Priority B) $T_A = +125^\circ\text{C}$ @ rated V_{RR} for 170 hours (Priority A)	
	Electrical (Priority A)	Reverse Current (I_{RC}) @ rated V_{RR} for 170 hours (Priority B) $T_A = +125^\circ\text{C}$ @ rated V_{RR} for 170 hours (Priority A)	
	Steady State Output (HTRP)	Reverse Current (I_{RC}) @ rated V_{RR} for 170 hours (Priority B) $T_A = +125^\circ\text{C}$ @ rated V_{RR} for 170 hours (Priority A)	
	Electrical (Priority B)	Reverse Current (I_{RC}) @ rated V_{RR} for 170 hours (Priority B) $T_A = +125^\circ\text{C}$ @ rated V_{RR} for 170 hours (Priority A)	
	Electrical (Priority A)	Reverse Current (I_{RC}) @ rated V_{RR} for 170 hours (Priority B) $T_A = +125^\circ\text{C}$ @ rated V_{RR} for 170 hours (Priority A)	
	Steady State Output (HTRP)	Reverse Current (I_{RC}) @ rated V_{RR} for 170 hours (Priority B) $T_A = +125^\circ\text{C}$ @ rated V_{RR} for 170 hours (Priority A)	
	Electrical (Priority B)	Reverse Current (I_{RC}) @ rated V_{RR} for 170 hours (Priority B) $T_A = +125^\circ\text{C}$ @ rated V_{RR} for 170 hours (Priority A)	
SUBGROUP 4	Design Verification Test	2016	1
	Load Strength	71 wires	
SUBGROUP 5	Not applicable		1
SUBGROUP 6	Electrical (Procedures A & B)	Reverse Current (I_{RC}) @ rated V_{RR} Breakdown Voltage (V_{BR}) @ I_{BR}	1
	High Temperature Life (HTRP)	4016 4022	
	Electrical	4016 4022	
	Reverse Current (I_{RC}) @ rated V_{RR} for 340 hours $T_A = +125^\circ\text{C}$ @ rated V_{RR} for 340 hours	4016 4022	

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MiniApp One

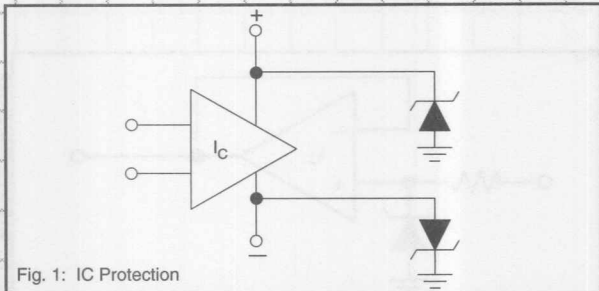


Fig. 1: IC Protection

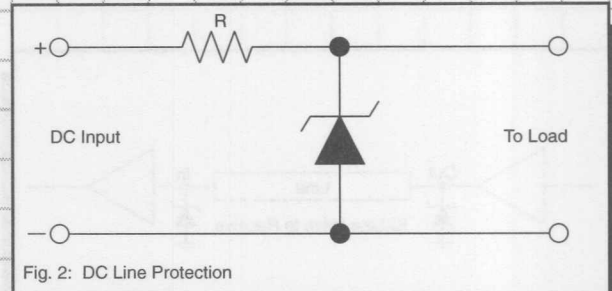


Fig. 2: DC Line Protection

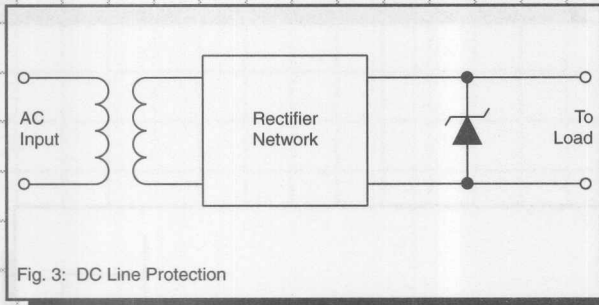


Fig. 3: DC Line Protection

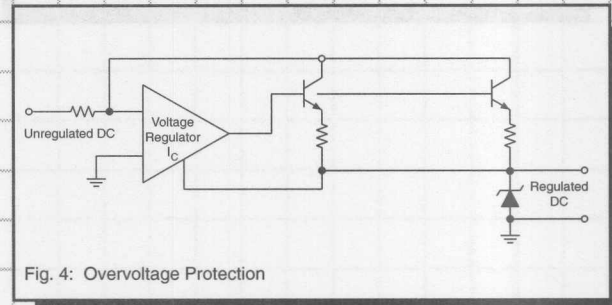


Fig. 4: Overvoltage Protection

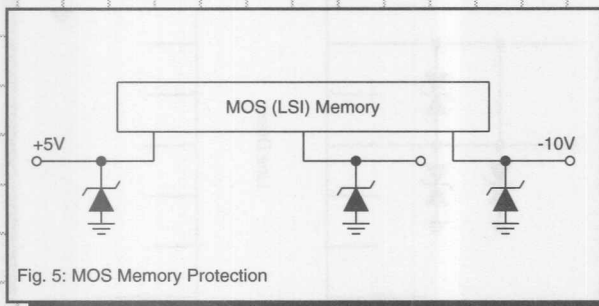


Fig. 5: MOS Memory Protection

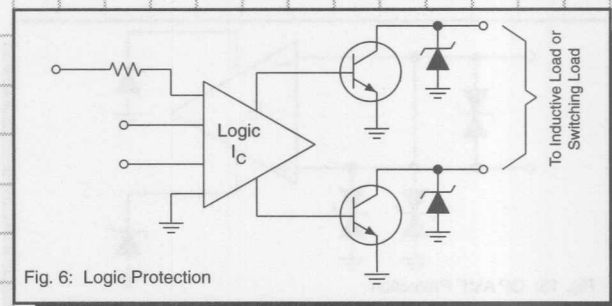


Fig. 6: Logic Protection

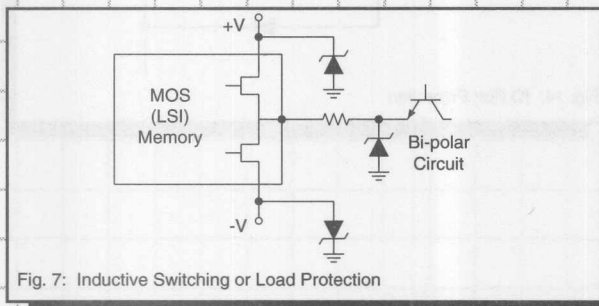


Fig. 7: Inductive Switching or Load Protection

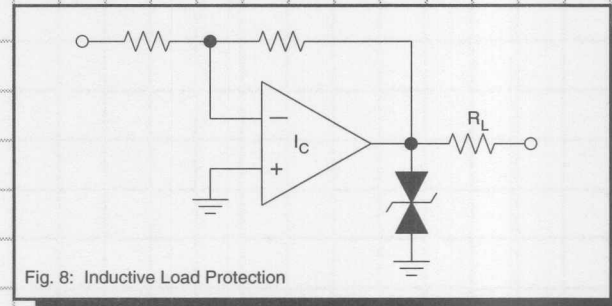


Fig. 8: Inductive Load Protection

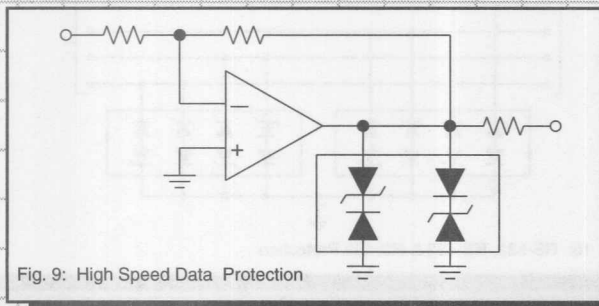


Fig. 9: High Speed Data Protection

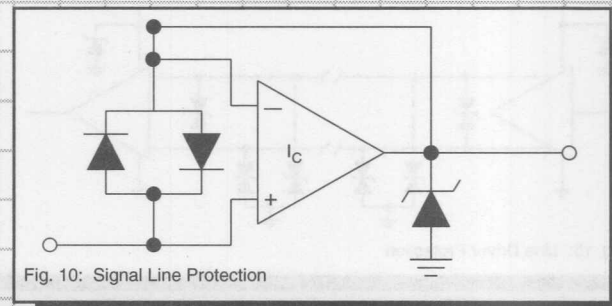
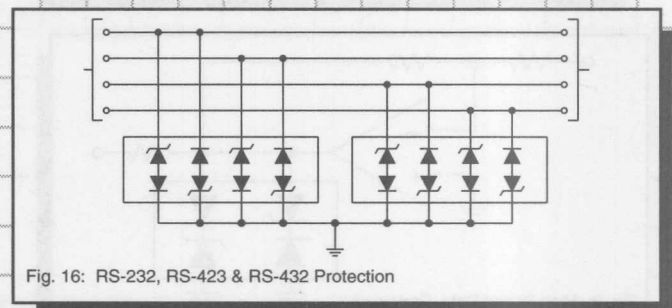
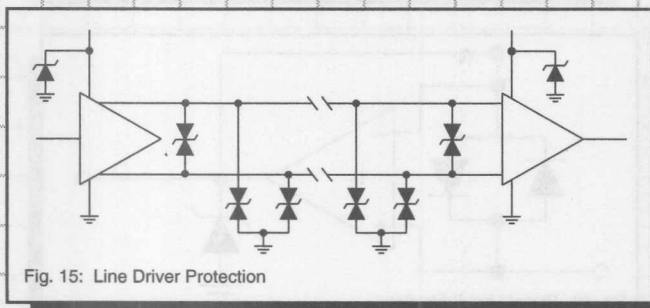
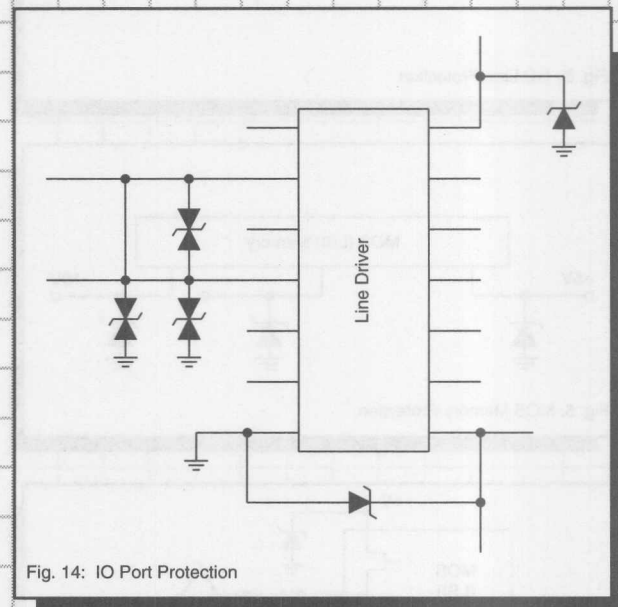
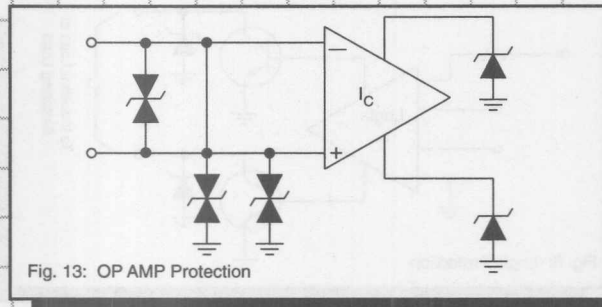
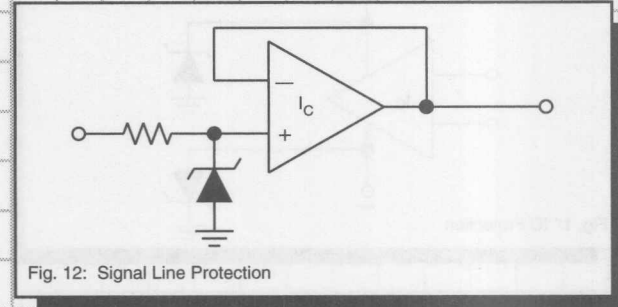
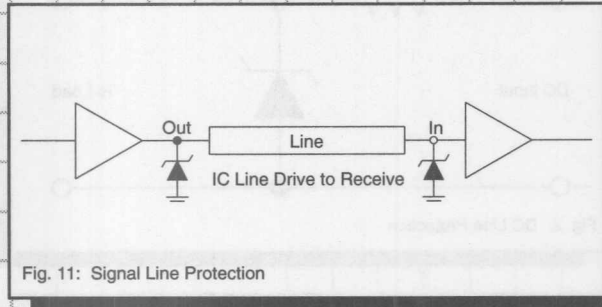
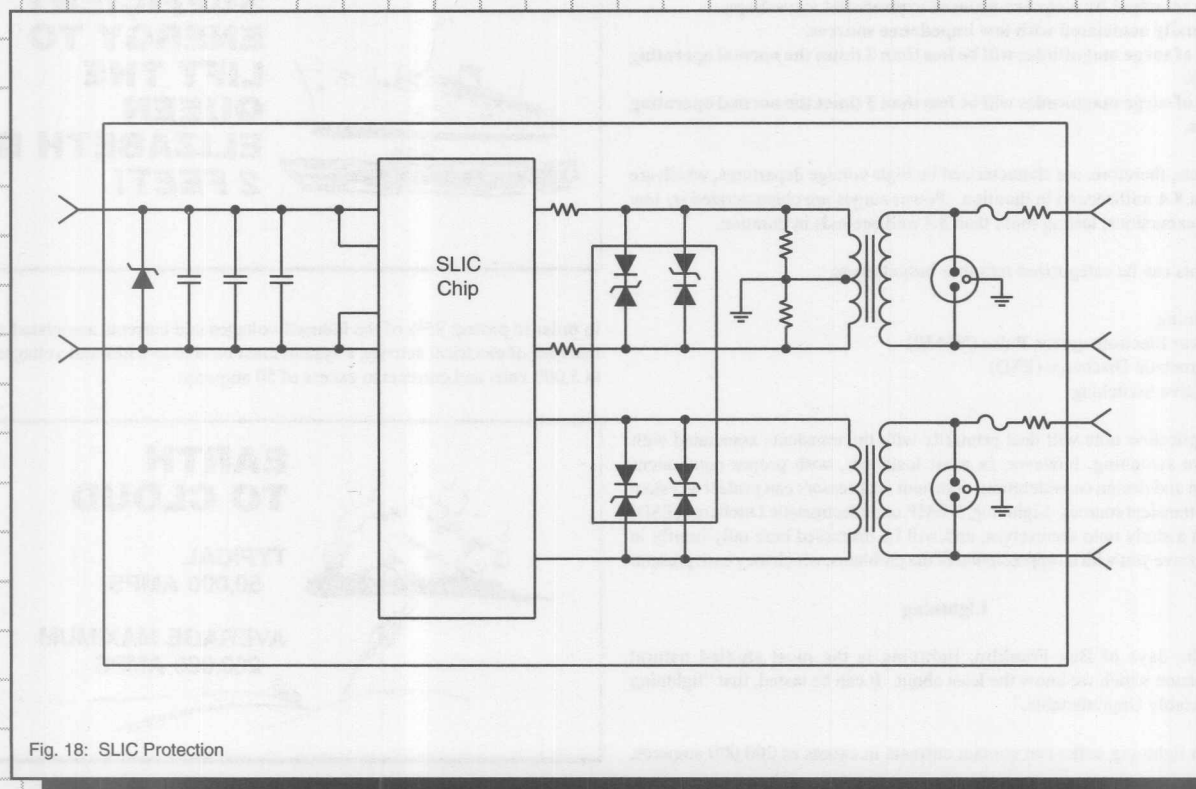
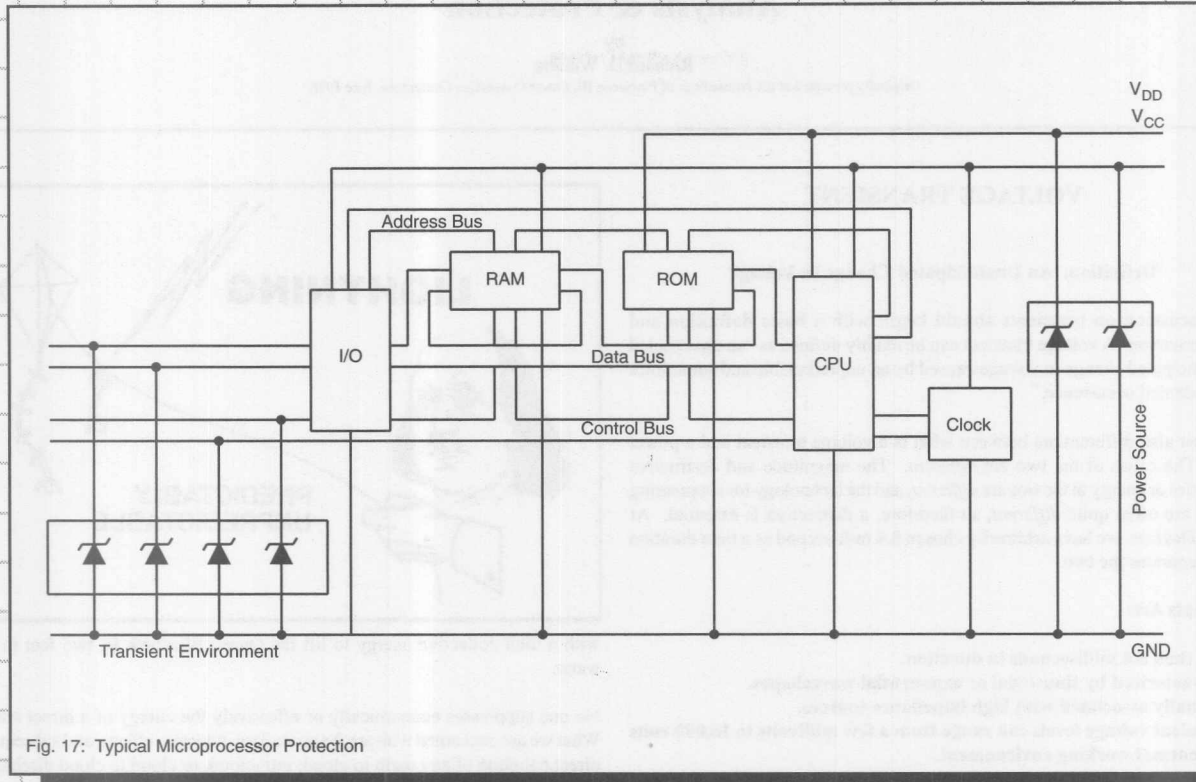


Fig. 10: Signal Line Protection

MiniApp Two



MiniApp Three



Power Supply Voltage Transient Analysis & Protection

by

Richard D. Winters

Originally presented at the Proceedings of Powercon III, Power Conversion Conference, June 1976.

VOLTAGE TRANSIENT

Definition: An Unanticipated Change In Voltage

Any discussion on transients should begin with a basic definition and characterization. A voltage transient can be readily defined as "an unexpected or unanticipated change in voltage caused by an unpredictable and sometimes unprecedented occurrence."

One must also differentiate between what is a voltage transient and a power surge. The cause of the two are *different*. The magnitude and destructive capabilities or energy in the two are *different*, and the technology for suppressing the two are often quite *different*, so therefore, a distinction is essential. At ProTek Devices, we have arbitrarily chosen 8.4 millisecond as a time duration which separates the two.

Transients Are:

1. Less than 8.4 milliseconds in duration.
2. Characterized by sinusoidal or exponential waveshapes.
3. Normally associated with high impedance sources.
4. Transient voltage levels can range from a few millivolts to 18,000 volts in a normal working environment.

Surges Are:

1. Greater than 8.4 milliseconds in duration.
2. Characterized by a square wave or exponential waveshape.
3. Normally associated with low impedance sources.
4. 90% of surge magnitudes will be less than 2 times the normal operating levels.
5. 99% of surge magnitudes will be less than 3 times the normal operating levels.

Transients, therefore, are characterized by high-voltage departures, which are less than 8.4 millisecond in duration. Power surges are characterized by low voltage excursions, lasting more than 8.4 milliseconds in duration.

Transients can be categorized into four basic threats:

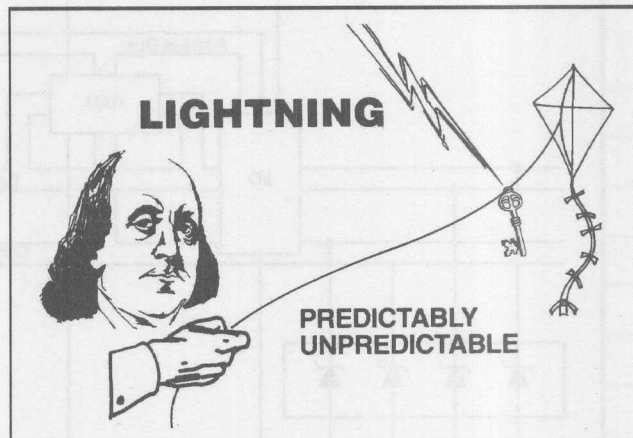
1. Lightning
2. Nuclear Electromagnetic Pulse (NEMP)
3. Electrostatic Discharge (ESD)
4. Inductive Switching

This application note will deal primarily with the transients associated with inductive switching, however, in most instances, with proper component selection and design consideration, transient suppressors can protect a system from all transient sources. Lightning, NEMP, and Electrostatic Discharge (ESD) are each a study unto themselves, and will be discussed here only briefly in order to leave you with an appreciation of the problems, which they each present.

Lightning

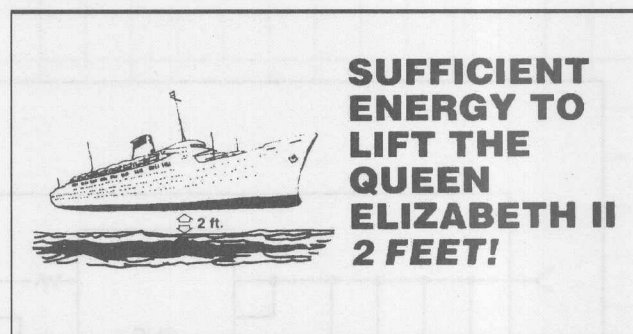
Since the days of Ben Franklin, lightning is the most studied natural phenomenon which we know the least about. It can be stated, that "lightning is Predictably Unpredictable."

A return lightning strike can contain currents in excess of 200,000 amperes,

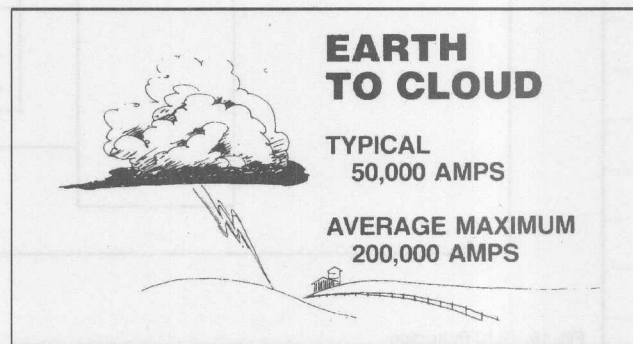


with a total collective energy to lift the Queen Elizabeth II, two feet in the water.

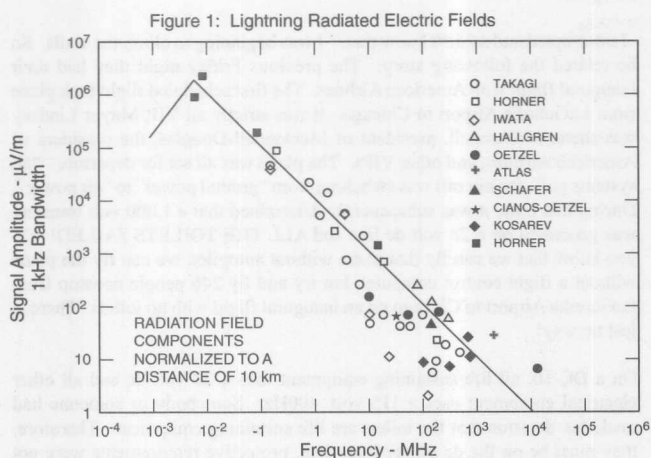
No one suppresses economically or effectively the energy of a direct strike. What we are concerned with are the secondary inductive effects, and subsequent direct coupling of any earth to cloud, intracloud, or cloud to cloud discharge.



In order to protect 95% of the induced voltages and currents associated with this type of electrical activity, a system must be able to withstand voltages up to 5,000 volts and currents in excess of 50 amperes.



In 1972 the Stanford Research Institute published a report on the effects of lightning¹. Included in this report were two extremely interesting studies (See Table 1 & Figure 1) which documented the effects of induced lightning.



The following effects were included: maximum peak amplitude in volts normalized at 10 kilometers and static magnetic fields in amps per meter.

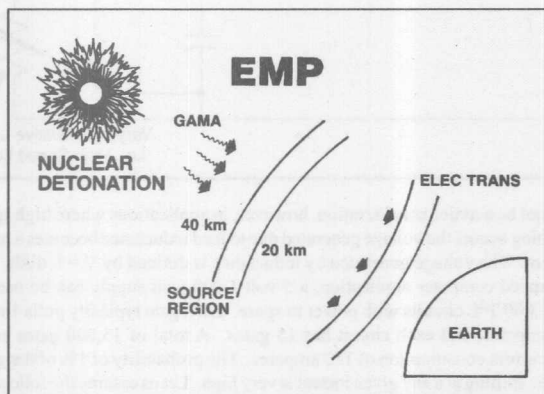
PEAK CURRENT kA	STATIC MAGNETIC FIELD (A/m)		
	10m FROM FLASH	100m FROM FLASH	10km FROM FLASH
10	1.6×10^2	16	1.9×10^{-2}
20	3.2×10^2	32	3.8×10^{-2}
30	4.8×10^2	48	5.8×10^{-2}
70	1.1×10^3	1.1×10^2	13×10^{-2}
100	1.6×10^3	1.6×10^2	19×10^{-2}
140	2.2×10^3	2.2×10^2	27×10^{-2}
200	3.2×10^3	3.2×10^2	38×10^{-2}

Table 1: Static Magnetic Fields From Close Lighting

Nuclear Electromagnetic Pulse (NEMP)

Nuclear Electromagnetic Pulse (NEMP) have certain characteristics which relate directly to the characteristics one would encounter with electrostatic discharge. Specifically, fast rise times and large voltage potentials.

During a high altitude nuclear detonation, gamma rays are released which set into motion high speed electrons. Subsequently, these electrons are curved or



¹ N. Cianos & E. T. Pierce, A Ground-Lightning Environment For Engineering Usage, Stanford Research Institute, pp. 105 & 111, August 1972.

partially deflected by the electromagnetic belt surrounding the earth. This reaction creates an electromagnetic pulse. The upset occurring by this deflection generates a voltage pulse of 50,000 volts per meter - 300 miles from the actual point of detonation - with a rise time of approximately 5,000 volts per nanosecond.

TRANSIENT	FIELD DENSITY OR MAGNITUDE	RISE TIME
NEMP	50kV/m @ 500 km	5KV/ηs
LIGHTNING	3kV/m @ 10 km	600V/μS
STATIC DISCHARGE	20kV/m @ Impact	2KV/ηs

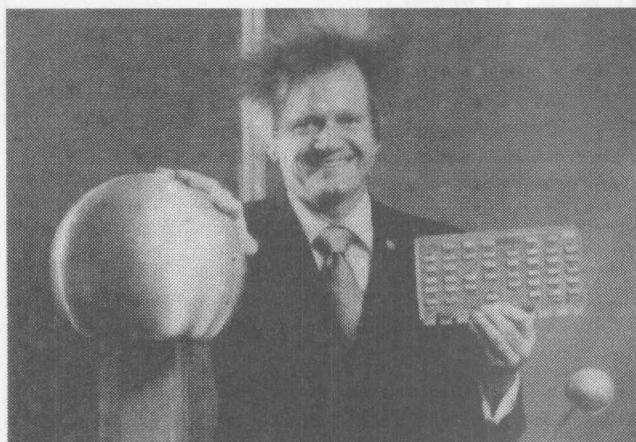
Table 2: Transient Field Density & Rise Times

In a small way NEMP is comparable to lightning which has a field density of 3 volts per meter, six miles from point of discharge, with a rise time of 600 volts per microsecond (See Table 2). Because NEMP has a large magnitude and frequency spectrum, there are no available "off-the-shelf" R-C or L-C filters that can effectively reduce or eliminate NEMP pulses.

Electrostatic Discharge (ESD)

According to studies made at Sandia Laboratories, in Albuquerque, normal body electrostatic discharge has a rise time of 2 kilovolts per nanosecond, with voltage magnitudes in excess of 20,000 volts.

It is interesting to note that a normal charge in identical conditions from a man is approximately 16,000 volts, whereas a woman could have a charge buildup of approximately 20,000 volts. Body chemistry is different between men and women, which contributes to a significant variance in the dielectric, and this accounts for the large charge buildup in women. Body capacitance can vary from 80 to 500 pF at the extremes with a discharge resistance of 50 to 5,000 ohms.



Inductive Transients In Power Supplies

A switching power supply designer is confronted with transients from all sides: the power source, the load, and the power supply itself. First of all let's look at the power source as a significant transient generator (See Figure 2). Quite often the power supply is destined to be used in an application which has been defined by a military specification such as MIL-STD-704, for aircraft power; MIL-STD-1399, for shipboard application; and MIL-STD-1275 for mobile vehicles. In addition, the designer must consider commercial power limits and various types of switching equipment and power surges associated with

electrical distribution. The power source is also subjected to environmental conditions, such as, lightning, auxiliary power equipment, and various large inductive industrial loads. In other words, the power source is indeed, a generator of innumerable transients of which the design engineer has no control (See Figure 3).

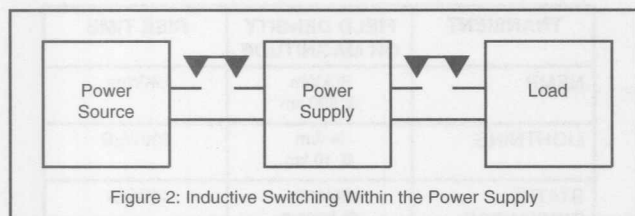
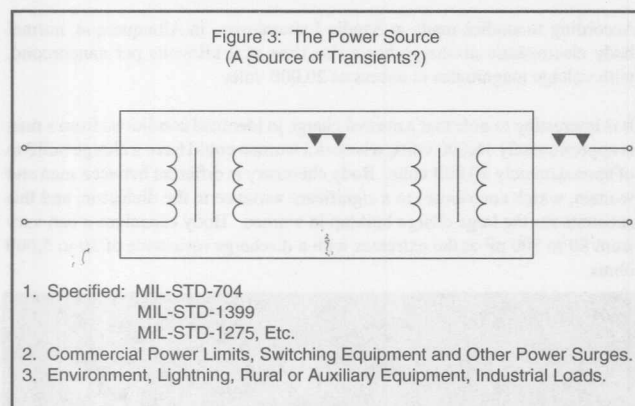


Figure 2: Inductive Switching Within the Power Supply

Specified power source transients can be real, imagined, or wishful thinking. There is probably no better example of this than MIL-STD-704, which was issued as a fully coordinated standard in October of 1959. It replaced MIL-E-7894, which was developed in controversy between Aircraft Electrical System Designers and Utilization Equipment Designers. Aircraft Electrical System Designers tried to maintain wider limits while Utilization Equipment Designers tried to narrow the same limits. The original MIL-STD-704 made no recognition of spikes or voltage transients. However, spikes did exist and so did systems failures. In 1967, ARINC (Aeronautical Radio, Inc.) published a study which vehemently attacked MIL-STD-704, and in essence said, "Damned



if you do, and damned if you don't."² If one abided by MIL-STD-704 and protected in terms of a worse case situation, the cost of incorporating maximum transient protection put the supplier in a noncompetitive situation. On the other hand, because the short duration transients were not documented, transient generated systems failures were a reality.

I want to share one MIL-STD-704 experience with you. Transients and power surges are virtually rampant on commercial aircraft - the DC-10 being no exception.

During my years at General Semiconductor Industries, I worked with many major airframe manufacturers on aircraft transients. Back in the early days when the DC-10 was being designed, we gave several seminars and technical presentations to McDonnell-Douglas, Long Beach. Subsequently, TransZorb® voltage suppressors were used throughout the aircraft; the radar, flight control computer, autopilot, electronic altimeter, windshield wiper control, anti-skid, and even unsophisticated systems such as an electronic coffee brewer. Needless to say, it was a very successful program for us.

Approximately three years ago I received a call from Don Shepard, Interior Electrical Systems Director for the DC-10. It was very early on a Monday morning and Don said, "Dick we got a problem." I could just picture in my mind all our little TransZorbs going up in smoke. So, very anxiously, I asked him what had happened. Don said, "I'm sure you know we are using your TransZorb® suppressors on the DC-10."

"Yes, I am very well aware of that."

"Well, we used them on the autopilot, we used them on the radar, we used them on the anti-skid devices, and we used them on the flight control computer."

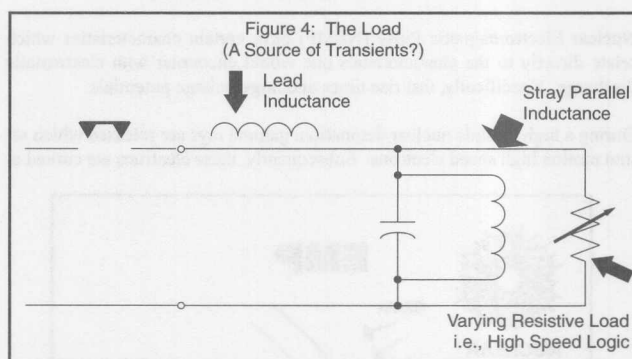
I interrupted and said, "I know that." I was beginning to climb the walls. So he related the following story: The previous Friday night they had their inaugural flight with American Airlines. The first scheduled flight took place from LaGuardia Airport to Chicago. It was strictly all VIP, Mayor Lindsey was there, McDonnell, president of McDonnell-Douglas, the president of American Airlines, and other VIPs. The plane was all set for departure - "all systems go" - the aircraft was switching from "ground power" to "air power". During this time, it was subsequently determined that a 1,000 volt transient was generated on a 28 volt dc line and ALL THE TOILETS FAILED! Do you know that we can fly that plane without autopilot, we can fly the plane without a flight control computer, but try and fly 246 people nonstop from LaGuardia Airport to Chicago on an inaugural flight with no toilets. There is just no way!

On a DC-10, all life sustaining equipment uses a 28 volt dc and all other electrical equipment uses a 115 volt, 400Hz. Somebody or someone had made the decision that the toilets are life sustaining equipment. Therefore, they must be on the dc power line. But, protective requirements were not incorporated in the specification. Today, we safely say that TransZorbs are used from the radar in the "front-end" to the toilets in the "rear".

The MIL-STD-1399 specification, covering shipboard electrical power, documents the 2,500 volt spike or transient. On numerous occasions the system designers have interpreted this specification utilizing worse case conditions. When that happens MIL-STD-1399 comes out as ambiguous as MIL-STD-704 because the worse case source impedance on a ship becomes the impedance of the generator, which is approximately 30 milliohms. Based on an I^2R situation, with a 2,500 volt spike, the transient surge is 200 megawatts!!! Now, we can talk about Grand Cooley Dam or Boulder Dam, but we certainly don't want to talk about a ship. As I stated earlier, specified Power Source Transients can be real, imagined, or wishful thinking.

The Load: A Source of Transients?

A power supply load is always a potential transient generator (See Figure 4). The load can consist of lead inductance, stray parallel inductance, a varying resistive load or a partially inductive load. In many situations, lead inductance



need not be a major consideration, however, in applications where high speed switching occurs the voltage generated due to lead inductance becomes a major concern. The voltage generated by inductance is defined by $V = L di/dt$. In a high speed computer application, a 5 volt 1,000 watt supply can be used to feed 1,000 T^2L circuits with power to spare. Each gate typically pulls 1 to 10 milliamperes, and each circuit has 15 gates. A total of 15,000 gates could have current consumption of 150 amperes. The probability of 1% of the gates or logic shifting at a any given instant is very high. Let us assume the following:

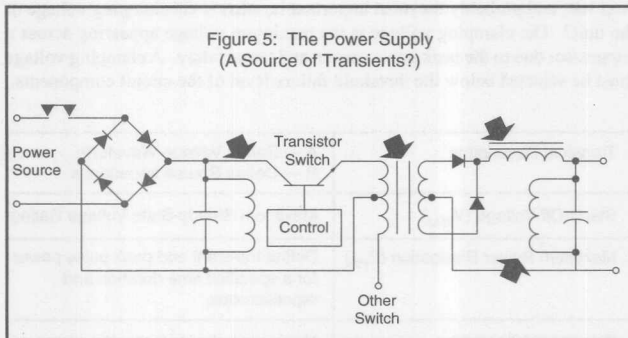
² "Guidance for Aircraft Electrical Power Utilization & Transient Protection", ARINC Specification No. 413, May 1, 1967.

1. Lead length from the power supply to the logic board is 3 meters.
2. The inductance of the lead is 10-6H/meter.
3. The switching time of the T²L logic is 20 nanoseconds.

We now have a transient generator capable of producing anywhere from 23 volts to 225 volts on the 5 volt logic bus. The "overvoltage protector," the "remote voltage sense," and a current foldback system have no effect or protective capabilities which shunt the fast rise time transient.

The Power Supply: A Source Of Transients?

Without a doubt the switching power supply is a source of transients (See Figure 5). Not only is it a transient generator, it is an EMI generator, a surge generator, and to semiconductor manufacturers of switching transistors, a transistor destroyer. The transient producing elements of a power supply are primarily:



1. The filter circuits consisting of a filter capacitor and sometimes a large filter inductor.
2. The switching transistor in conjunction with the inverter transformer.

Both the storage time and the fall time of the transistor have an effect on the transient waveform with respect to voltage magnitude and duration. The harder the transistor is driven the faster the fall time, the higher the magnitude of the spike voltage which is generated by the output transformer. Most switching circuits today utilize transistors with a VCEO two and one-half times the supply voltage and a "clamp" or "snubber" circuit to cope with self-generated spikes.

The power supply is in a very unique, if not hazardous situation. Not only is it faced with transients from the power source, transients from the load, but it must also be able to operate with its own internally generated transients.

In a switching environment, many electronic components are subjected to a "wear-out" phenomenon, in other words, the components gradually degrade in their functional parameters to the point that they are no longer within their electrical tolerances, and the power supply or electronic equipment becomes inoperative, making reliability a major consideration.

TYPE	MINIMUM JOULE ENERGY	MATERIAL	FUNCTION
MC715	8×10^{-5}	Si	Data Input Gate Integrated Circuit
2N1066	3×10^{-4}	Ge	PNP HF Drift Transistor
RCA CA3005	8×10^{-6}	Si	RF Analog Integrated Circuit
1N3659	8×10^{-3}	Si	Automotive Rectifier Diode
1N457	3×10^{-4}	Si	General Purpose Diode
1N277	2×10^{-5}	Si	High Speed Switching Diode
1N647	2×10^{-3}	Si	General Purpose Diode
1N538	6×10^{-4}	Si	Rectifier Diode
1N126A	1×10^{-5}	Ge	General Purpose Diode
1N23B	1×10^{-7}	Si	Microwave Diode
2N3528	3×10^{-3}	Si	Silicon Controlled Rectifier

Table 2: Semiconductor Device Failure Thresholds

Failure Threshold

The design engineer should be aware that it is not necessarily the total energy within any transient that is the destructive element to his semiconductors, but quite often the voltage magnitude which causes the breakdown within the intrinsic region of a semiconductor, or in some cases, the breakdown of the electrical insulation or passivation.

The following table (See Table 2) shows the failure threshold of various semiconductors to fast rise time pulses. It is a proven fact that the energy capability or withstand surge capability of a semiconductor decreases rapidly as the rise time of the pulse increases, in other words, the threshold of failure is significantly lower with fast rise time pulses.

THE SOLUTION

The Capacitor

Transients are normally associated with high frequency components which are several orders of magnitude above the steady state voltage frequency. The obvious solution is to install a low pass filter. The simplest form of a filter is a capacitor, and hopefully, the capacitor will present a much lower impedance than the transient source, forming a voltage divider. A capacitor, whether it is in the power supply, on the load, or on the power source, works quite well as long as it:

1. Does not load down the system and does not create any current "inrush" problems (See Figure 6).

Figure 6: Effects of an "inrush" problem on a Capacitor.

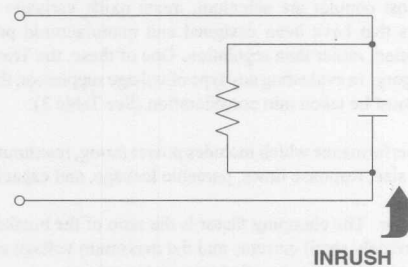
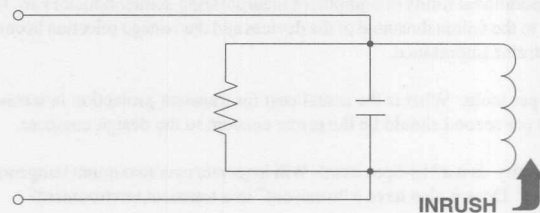


Figure 7: The effects of parasitic inductance on a Capacitor.



2. Does not have any parasitic inductance which will spoil the high frequency admittance of the device (See Figure 7)
3. Does not degrade with time or ripple current.

Sometimes a resistor in series will reduce the current "inrush" problem, but then it also reduces the effectiveness of the capacitor (See Figure 8).

If the transient has high dc current components in either polarity, the capacitor will also become ineffective and the inductance associated with our filter resistor will also reduce the effectiveness (See Figure 9)

In addition, transient oscillations or ringing can develop. When that happens our capacitor can have the effect of increasing the transient voltage if the

transient source is inductive. As can be seen from these figures (See Figure 9), a simple capacitor filter is now, not quite so simple.

Figure 8: The effects of series "inrush" problems on a capacitor.

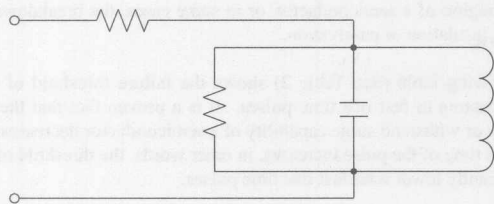
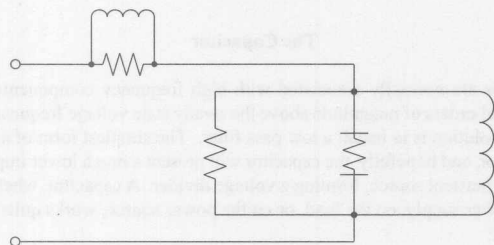


Figure 9: The effects of high dc current on a capacitor.



Transient Voltage Suppressors

Most transient voltage suppressors are characterized by a clamping, Zener-ing or avalanching action. There are several types of these products available on the market. Most popular are selenium, metal oxide varistors and silicon junction devices that have been designed and manufactured primarily for voltage suppression, rather than regulation. One of these, the TransZorb®, is of the latter category. In evaluating any type of voltage suppressor, the following characteristics must be taken into consideration (See Table 3):

1. The overall performance which includes power rating, maximum operating temperature, size, response times, parasitic leakage, and capacitance.
2. Clamping factor. The clamping factor is the ratio of the breakdown of the device at extremely small currents and the maximum voltage appearing across the device during a specified transient condition.
3. Available voltage. What is the selection of available voltages? Quite often the operational limits of equipment incorporating semiconductors are very close to the failure threshold of the devices and the voltage selection becomes of extreme importance.
4. Cost per joule. What is the actual cost for transient protection in terms of watts per second should be the prime concern to the design engineer.
5. Reliability. Is it a Mil-Spec item? Will it operate over maximum temperature ranges? Does it also have a "wear-out" in a transient environment?

	SELENIUM	VARISTOR	TRANSZORB (Silicon Junction)
Overall Performance	Poor	Better	Best
Clamping Factor	Poor	Better	Best
Voltage Availability	Poor	Better	Best
Cost Per Joule	Better	Best	Poor*
Reliability	Poor	Better	Best

*On a dollar per watt or per joule. Silicon devices are two times the cost.

Table 3: Comparison of Voltage Suppressors

Selecting A Transient Suppressor

In selecting the transient suppressor for the application, one first must be able to describe or evaluate the transient conditions (See Table 4).

1. The transient waveform should be defined both with respect to the source impedance and voltage or peak current. The voltage or peak current waveform can best be described as an impulse on a decaying damped sine wave.
2. The "stand-off" voltage should be selected. This voltage is equal to or slightly greater than the maximum steady state voltage rating of the equipment.
3. A determination must be made of the maximum power dissipation, which includes repetition rate.

And last, and probably the most important is, what is the clamping voltage of the unit? The clamping voltage is the maximum voltage appearing across a suppressor due to the peak pulse current and temperature. A clamping voltage must be selected below the threshold failure level of the circuit components.

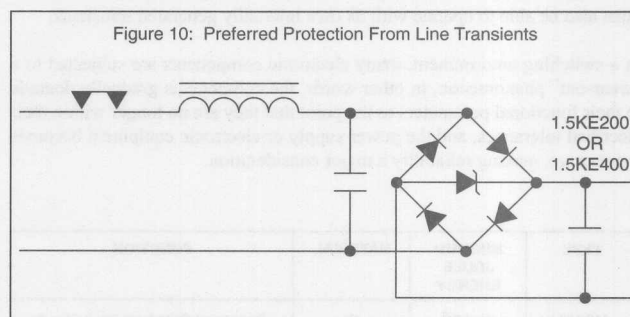
Transient Description	A — Define Voltage Waveform B — Define Source Impedance
Stand-Off Voltage (V_{WM})	Maximum Steady-State Voltage Rating
Maximum Power Dissipation (P_{PP})	Define transient and peak pulse power for a specified time duration and repetition rate.
Clamping Voltage (V_C)	Maximum voltage appearing across a suppressor due to the peak power current and temperature.

Table 4: Selection Guide

Protecting The Power Switching Supply

The following illustrations depict various methods of protecting voltage sensitive elements within the switching power supply (See Figures 10-14).

TransZorbs placed across the bridge rectifier will clamp most line transient or load "spikes". (It should be noted that the rectifier diode peak surge current ratings must be compatible with the maximum surge current expected through the TransZorb. Selection of the appropriate TransZorb would proceed as follows:

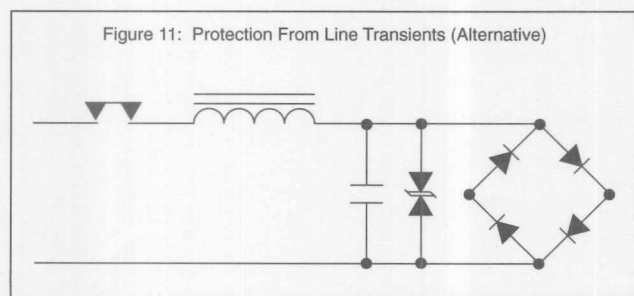


1. Determine the maximum dc plus peak ripple voltage, then add the high side tolerance to this value.
2. Select a TransZorb® to have a reverse stand-off voltage equal to or greater than the maximum circuit voltage, as defined in 1 above. This selection will allow for operating over the temperature range of -55°C to $+150^{\circ}\text{C}$.
3. Define the wave shape or duration of the transient.

4. Determine the peak pulse current the TransZorb® will be required to pass. Check this against the maximum Peak Pulse Current shown on the TransZorb® data sheet. If the predicted current exceeds the device rating, don't despair - as covered later in this discussion - something can be done.
5. If the current to be handled is within the device rating, proceed to determine the maximum peak pulse current by the maximum clamping voltage of the selected TransZorb®.
6. If peak pulse power is within the maximum rating of the TransZorb®, use the device selected.

To evaluate this, the following criteria should be used:

- a) For a transient pulse width of an exponential delay, define "pulse time" as the duration of the pulse from the 10% amplitude point on the leading edge to the 50% amplitude point on the trailing edge. From the TransZorb® data sheet chart of "Peak Pulse Power vs. Pulse Time," determine the peak pulse power rating of the device for the computed "Pulse Time" of the incident pulse.
 - b) For transients which approximate a "sine wave" in pulse wave shape, use the total pulse width as the "Pulse Time" and multiply the corresponding "Peak Pulse Power" value by 0.75 to obtain the effective TransZorb® rating.
 - c) For "Square Wave" shaped transients, multiply the "Peak Pulse Power" value for the corresponding pulse time by 0.66 to obtain the effective TransZorb® rating.
 - d) If the transient is a rapidly damped sine wave, or a rapidly damped square wave, with a one time constant within eight cycles, rate the same as if the device were subjected to just one cycle (highest amplitude) of the wave train.
 - e) For any other transient conditions, consideration must be given to the average power handling capability of the device and/or the total transient energy must be summed and evaluated in respect to thermal deratings.
7. If the peak pulse power of the incident pulse is greater than the rating of the TransZorb, devices may be "stacked" in series to increase the power rating for voltages above 16 volts. Notice that, when stacking the same Power Rating devices, the current rating goes up in proportion to the number of devices stacked! If it is impossible to achieve the necessary power rating by stacking the devices in series, parallel stacking can be done effectively for voltages below 100 volts. Close matching above 200mV between each device is necessary to assure even loading of the transient between the TransZorbs. Series/parallel stacking can be done for higher voltages and powers. This must be done at the factory for optimum results.
 8. Observe the maximum clamping voltage, which is 1.33 times the Breakdown Voltage. If this is greater than what the circuit can withstand, devices can be constructed to reduce the clamping factor of approximately 1.2 as compared to the 1.33 clamping factor for a single device.
 9. Surge protection assemblies are also available when it is necessary to "short" extremely large current pulses. This assembly utilizes a gas gap with the TransZorb®. Requests for this type of protection product must be coordinated with the factory.

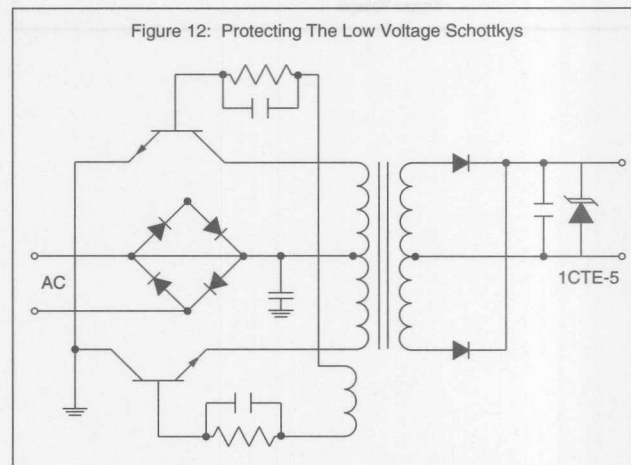


Alternate

In a situation where the surge currents to be handled by the TransZorb® would overstress the rectifier diodes, a bipolar TransZorb® can be used directly across the input filter capacitor with equal line shunting effectiveness (See Figure 11).

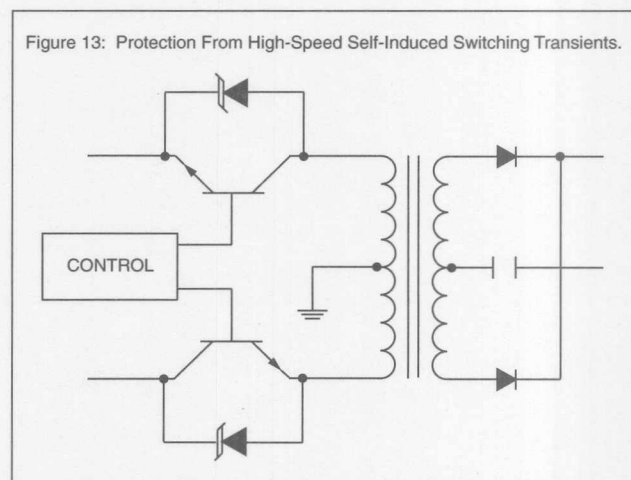
Low Voltage Schottkys

Placing a second TransZorb across the output terminals of the Schottky rectifiers, as shown in Figure 12, provides protection for the Schottky devices from any load voltage transients and simultaneously provides effective protection from any secondary leakage inductance voltage "spikes."



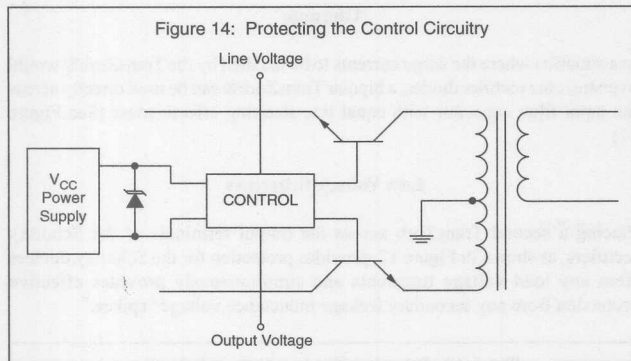
Self-Induced Switching Transients

A TransZorb® "clamp" placed across the collector-emitter of each of the switches provide a high degree of protection against transient voltages which occur when the transistor is switched to its "off" state (See Figure 13). The use of appropriate collector-emitter reverse voltage clamps can completely eliminate any danger of the device ever switching through the energy sensitive ES/B region.



Protecting the Control Circuitry

Often the designer can overlook the effect of power supply transients, whether self induced or due to coupling paths from other system networks. A TransZorb® "clamp", placed across the supply terminals of sensitive control networks can avoid catastrophic failures due to line transients, supply glitches, or transients induced in the system due to unrelated system failures (See Figure 14).



Conclusion

Performance and reliability should be the prime concern of the switching power supply design engineer. Transients have been around for a long time and they are not about to go away. What concerns us all is the selecting the right device, for the right application, at the least possible cost to the end user.

TVS Device Selection, Location & Connection For EMC Design

by
David W. Hutchins
ProTek Devices, 1998

Electromagnetic Compatibility (EMC), one of many the environments influencing circuit design and board layout today, encompasses both radiated emissions and transients immunity threats. Basic protection from these threats can be achieved through good engineering practices, such as shielding, grounding, bonding and applying transient voltage suppression (TVS) devices at key interface locations. A TVS diverts potential current transients away from sensitive IC components and clamps the transient voltages below the withstand limits of the IC for a given pulse width. Due to the increased sensitivity and performance standards of IC components, circuits/systems cannot be designed without consideration of real world and industry standard immunity requirements. In order to meet industry standards for radiation and immunity, such as IEC 1000-4 specifications, selection, placement, and proper connection of a TVS in a circuit/system is most crucial. Additionally, consideration must be given to multiple ground planes (return paths) and shielding within a circuit.

SELECTION

There are three basic TVS selection criteria generic to all applications that must be observed in order to meet EMC compliance standards. These selection parameters are: 1) Stand-off Voltage (V_{WM}), 2) Peak Pulse Current (I_{PP}), and 3) Capacitance (C).

1) **Stand-off Voltage:** Transient voltage suppression devices are initially chosen according to their stand-off voltage (V_{WM}) which needs to be equal to or greater than the circuit operating voltage. For those applications where the signal is unidirectional, e.g., +5 volts to 0 volts, a unidirectional device is appropriate. A unidirectional device can also protect in both directions; however, the clamping voltage in the forward direction will be approximately 1 volt. A bidirectional device is suitable for those applications where the signal is both plus and minus, e.g., +12 volts to -12 volts.¹ Although a transient threat can be positive or negative or both in nature, the operating voltage range of a data line signal should dictate the selection of a TVS for this parameter.

2) **Peak Pulse Current:** Another important TVS criterion, is the maximum peak pulse current (I_{PP}) rating, which defines the maximum current handling capability for a given pulse duration (t_d). The current handling capability, which is referenced to a specific waveshape, is not a constant over time. A pulse duration (t_d) is defined as the front time plus its fall time. Front time is characterized by the length of time needed for the peak pulse current (I_{PP}) to reach its peak value as shown in Fig. 1, (a). The fall time is characterized as the length of time needed for the peak pulse current to reach 50% of its peak value as shown in Fig. 1, (b). The TVS maximum peak pulse current rating must be higher than the anticipated surge current.² These parameters are important in that the TVS must be capable of diverting the transient current without shorting and also providing a low clamping voltage for the protection of a circuit/system or IC component.³

3) **Capacitance:** The third criterion is capacitance. This parameter is important for high data rate applications or for long haul data transmission lines.

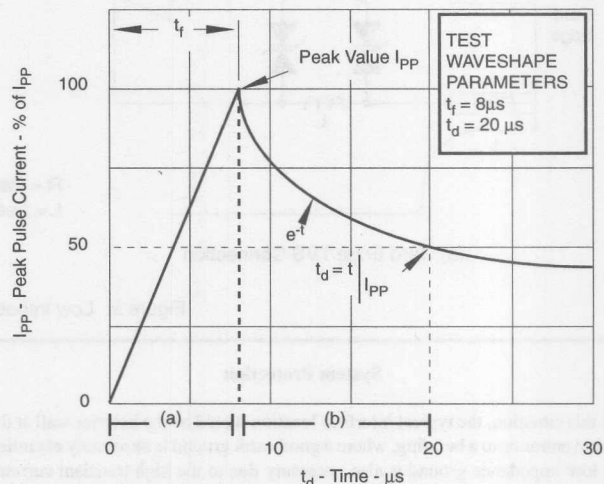


Figure 1: 8/20 μ s Pulse Waveshape

Capacitance can cause signal loss or be the cause of signal reflections if not properly utilized in a specific data rate application.⁴ In order to select a TVS device with regards to capacitance as well as for general protection against transient threats, it is recommended that the TVS be tested in the circuit under normal operating conditions.⁵

PLACEMENT

After a TVS has been selected for a specific application, the next step is placement within the circuit/system. The placement of a TVS must have the correct ground connection for the return path of the peak pulse transient current. A correct ground connection may be an earth-ground for systems; chassis-ground for equipment; and ground-plane for board level of which their may be three grounds: power bus, analog, and digital. To avoid voltage differentials between circuits or other grounds, the return path must be of low impedance. A low impedance path can be achieved through a good ground plane or a wide braided wire strap depending upon the interface location of the TVS and the source of the transient threat.

An example of a low impedance return path is where inductance is kept to a minimum as shown in Figure 2. A typical inductance of a PCB trace is given as 20nH per inch; which is a good rule of thumb when actual measured values cannot be obtained.

Inductance on the ground plane or return path will cause a damped sinusoidal voltage in excess of the incident pulse for fast transient events, such as ESD and EFT. This voltage can cause upset or damage to the IC component when it exceeds the rated pulsed withstand voltage.⁶

¹ Selection of a TVS device should be based upon the signal(data), which can be either unidirectional or bidirectional. This selection parameter should not be based on the nature of the transient threat.

² Peak pulse current ratings for a specified pulse duration can be calculated for any transient voltage suppression device. See Application Note: 080197, *Maximum Peak Pulse Current (I_{PP}) vs Pulse Duration (t_d) for TVS Devices*, Hutchins, David W., July 1997.

³ If the failure threshold voltage verses time is unknown for a specific component, circuit testing is advised.

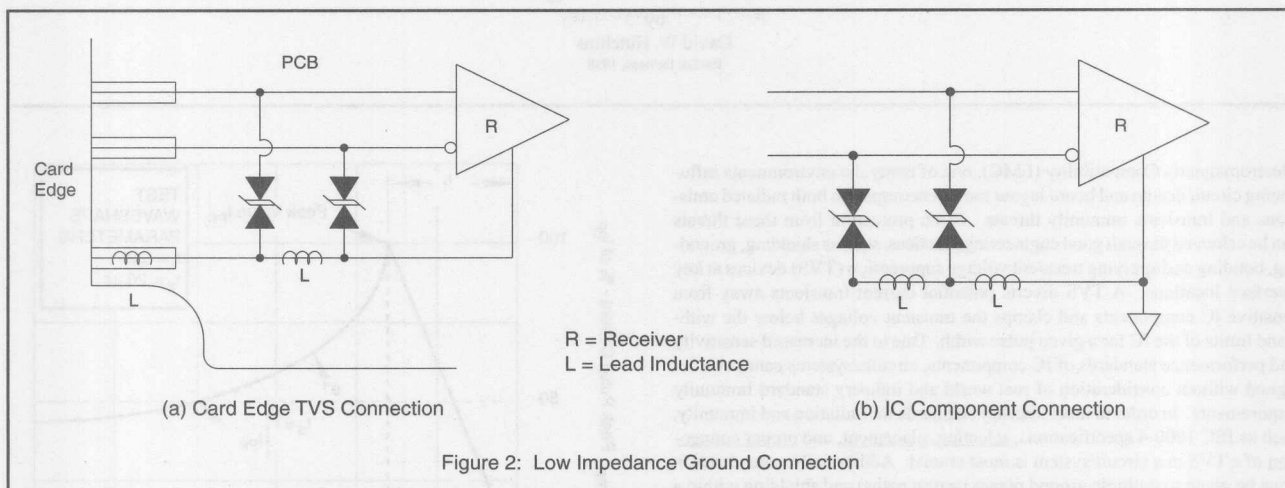
⁴ See Application Note: 073197, *Transient Voltage Suppressor Capacitance: Considerations For Data Line Applications*, Hutchins, David W., July 1997.

⁵ Refer to the graph "Baud Rates vs TVS Capacitance", *Transient Voltage Protection Products*, ProTek Devices, Nov. 1996.

⁶ Pulse withstand voltage limits are not to be confused with the continuous operating voltage provided by the IC component manufacturer data sheets.

Factors that influence the design of a low inductance return path are trace width, trace length, and ground planes. Although many guidelines exist such as the 3:1 rule or the 5:1 rule for resistance; when it comes to inductance, it is important to test the circuit with regards to a specific application.

For those applications where EMI/RFI is either a major consideration or already a problem at the board level, the TVS should be physically placed in close proximity to the individual component that requires protection. Typically, a TVS device should be located within 0.1 inches from the sensitive IC



System Protection

In this situation, the typical interface location would be the exterior wall at the cable entrance to a building, where a good earth ground is absolutely essential. A low impedance ground is also necessary due to the high transient currents associated with lightning activity. The grounds running from the interface enclosure/panel should be as short as possible to the earth ground system, which minimizes the secondary effects of radiated energy. Both power ground and data ground connections should be at the same location. In this way, there is less of a chance for high voltage differentials to exist between the power, data or phone lines due to lightning transients. Where data lines extend to "off-premises" equipment, they require protection at a higher level, due to the fact that long lines (data or power) are subject to increased levels of both radiated (induced) and direct (nearby) strikes of lightning.

Equipment Protection

Another common interface location, is the equipment chassis, where its metalized surface acts as the largest area for a low impedance single point ground. As with the building interface, the equipment chassis serves as a common connection point for both power and data lines, as well as a barrier against radiated emissions. However, a TVS will only divert conducted transient currents back to the point of contact (entry) and cannot prevent radiated EMI/RFI emissions. Thus, it is important to eliminate the effects of radiated emissions and conducted current pulses at the equipment interface by shielding rather than allowing radiated fields and transient currents to affect sensitive IC components/circuitry.

Board Level Protection

Transient voltage suppressors are a desirable protection element at the card edge of a Printed Circuit Board (PCB). A typical TVS provides protection against conducted EMI/RFI emissions, all ESD events, switching transients, and tertiary lightning threats. These threats can be induced by the interconnecting cables and wires to the PCB. In addition, protection at the card edge prevents the transient from entering the card or having the ability to create secondary radiated EMI/RFI effects within the board. This principle applies to both data lines and power buses.

Although placement of a TVS at the card edge of a PCB can be a little difficult, this method of protection is preferred over installing a protection device in the connector cable assembly. It is much easier to have a low impedance ground point and single point ground for both power and data lines at the card edge of the PCB. However, it is important to keep in mind that a TVS will only protect against the conducted portion of the transient threat and not the radiated emissions. If this happens the radiated emissions can make the TVS appear to be ineffective.

component or as close as permitted by the board layout configuration. Where multiple lines are being protected, the TVS device should be located at a point where there is a low impedance ground return path back to the printed circuit board (PCB) card edge for each line. This is usually through a via (hole) to the ground plane on a multiple layer PCB. As with the first three protection locations, both the power bus connections and the data line inputs should be protected. In this case, the component is the item being isolated from the transient environment and voltage differentials that can upset or cause component failure. It is especially important that there is a low impedance ground plane for the transient current even at this location.

CONNECTION

Before placing the TVS on the board/system, one must determine whether the transient threat is differential or common mode. As an illustration, direct contact ESD events are either line to line or line to ground events where as air discharged ESD events are generally line to ground. For most applications, ESD can be considered a line to ground (common) transient event. ESD can also be line to line (differential) depending upon the source of the threat, i.e., Human Body Model (HMB) or Machine Model (MM).

Regardless of the threat source, it is essential to perform some type of surge testing on the circuit/system. This will make a difference in determining which two lines or line to ground connection the device is placed across.

Generally, a common ground connection should be made at the various system, equipment, and PCB locations. However, there are some designs that incorporate multiple grounds, such as analog and digital, where the connection is at some common point within the system, equipment, or card edge. At the desired protection location, there may be a difference in the ground planes by as much as one megaohm, with a withstand voltage of 750 to 1,000 volts. A TVS can be used between two ground planes to maintain a high resistance (isolation) and provide a low voltage differential for the purpose of limiting transient interaction between the two ground planes.

SUMMARY

The responsibility of selection, placement, and connection must be a joint effort between the circuit design engineer and the system designer. Selection of a TVS is a matter of knowing the circuit operating conditions, understanding the source of the transient threat, and determining the best interface location⁷. Consideration of these three points will provide access to cost-effective solutions and acceptable circuit performance both during the normal circuit operation and a transient event. By applying good engineering practices when designing to specific EMC standards, the end users will experience less loss of information (data) and system down time due to component failure after a transient event.



Understanding Network Interface (I/O Port) Protection

by
David W. Hutchins
ProTek Devices, 1998

With the increase in the number of network interface and immunity standards, selecting a transient voltage suppression (TVS) device for I/O port protection has become a very confusing process for today's design engineer. Not only must the protection device be compatible with these standards, it must also be capable of conducting/ diverting the transient current, clamp threats to their lowest voltage, and be properly packaged in accordance to its location on the printed circuit board (PCB). Then there is the issue of cost effectiveness!

The good news, a TVS can meet these basis conditions and provide the design engineer with some latitude in circuit design and layout. Moreover, with proper selection and placement of a TVS, additional problems such as EMI/ RFI noise from conducted or radiated disturbances can be prevented.

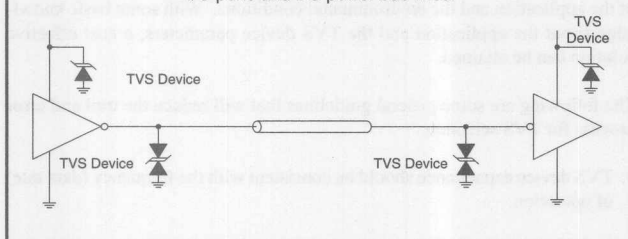
STAGES OF DESIGN

In the preliminary stages of design, the engineer begins with the selection of the IC components that are necessary to perform a defined system function. The IC component selection process also includes an appropriate interface (I/O Port) circuit or IC transceiver. In turn, the interface circuit has certain standards that must be met and taken into consideration by the designer. After the component(s) has been chosen, the circuit/system operating parameters, such as signal operating voltage and frequency (data rate), become evident. Lastly, the TVS device has parameters that need to be taken into account to be compatible with circuit performance and the EMC environment. Examples of these parameters are capacitance, stand-off voltage, and peak pulse current. Subsequently, these key circuit and device parameters along with the standard transient immunity requirements are the foundation for TVS device selection.

INTERFACE CIRCUIT CONFIGURATIONS

Part of the TVS device selection and placement process for data line transmission applications requires a fundamental knowledge of the interface circuit (I/O port) configurations. Interface circuits can be divided into two basic con-

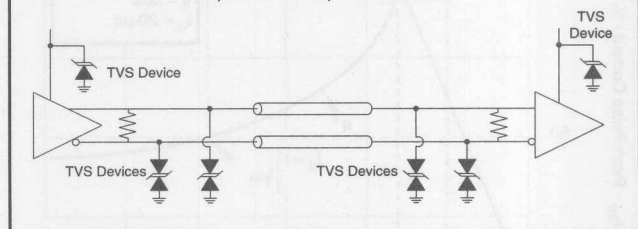
Figure 1: Unbalanced data line configuration showing TVS protection on the I/O ports and DC power bus lines.



figurations: balanced lines and unbalanced lines. As shown in Figure 1, a typical unbalanced line configuration consists of a line driver and a line receiver or a transceiver connected to a data transmission line. An unbalanced line uses the ground as the circuit return path. For some applications, there will be multiple unbalanced line transceivers in a given IC package requiring multiple TVS protection. Unbalanced lines can be more difficult in providing protection due to the various sources of transient threats such as lightning, ESD, and noise. For instance noise pickup can come from the power bus, signal lines or shared ground lines.

As shown in Figure 2, a typical balanced line configuration is comprised of differential I/O ports in which the ground is separate and not used as a signal

Figure 2: Balanced data line configuration showing TVS protection on the I/O ports and DC power bus lines.



return path. For balanced lines, the ground is typically connected to the IC component through the ground plane (trace) of the power bus at some single point location. However, due to common mode interference, it is important to have data line protection from each line to ground and from the power bus to ground.

Data lines will always require common mode protection against transient threats like electrostatic discharge (ESD) or induced lightning. In some cases, data lines will require differential mode protection to protect against electrical fast transients (EFT) or other switching transients. For example, if a switching transient becomes significant in magnitude, a TVS may be used between transmit and receive lines. However, a TVS placed across both lines to ground is sufficient for most circuit applications, as shown in Figure 2. Although TVS device selection is similar for both types of interface circuit configurations, there are some differences in the number of protection devices required for the circuit.

STANDARDS & PARAMETERS

Network interface standards such as RS 485, Ethernet, Firewire, USB, ISDN, ADSL, and SCSI define circuit/system performance and provide information for IC component selection. Once ascertained, network interface standards determine the circuit's frequency (data rate) and signal operating voltage. From this information, key parameters associated with the selection process of a TVS can be defined. Without knowledge of the above parameters, protection at board level will be hit and miss at best.

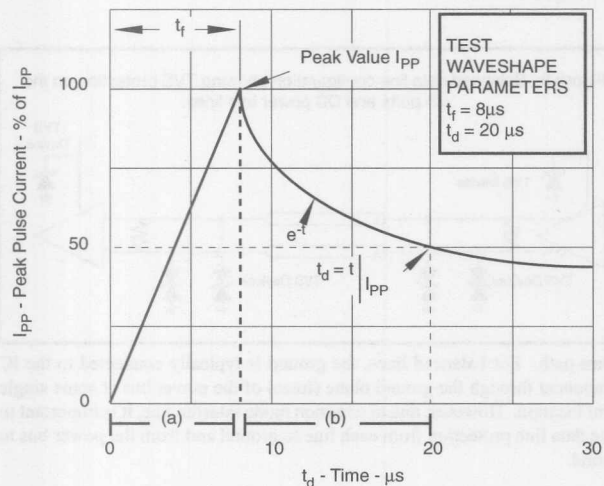
For an interface circuit to be consistent with network standards, TVS device capacitance must also be taken into consideration. Adding TVS capacitance is primarily based on the operating frequency and added parasitic capacitance is based on the transmission line distance. Too much line capacitance can distort the leading edge of a digital pulse and reduce the peak value of the signal below the required voltage limit.

Immunity standards such as IEC, EN, EOS/ESD, ANSI, IEEE, Bellcore, and ITU provide the engineer with the voltage, current, and waveshape parameters of the transient threat. For example, ANSI/IEEE C62.41, a standard for identifying lightning transients, provides a good estimate of peak pulse current ratings for short pulse durations using an 8/20 μ s or 10/1000 μ s waveshape. Likewise, EN50082 and IEC 1000-4 provide similar threat parameters for ESD and EFT.

Figure 3 shows a typical 8/20 μ s current waveshape (A similar waveshape, but with a faster rise time and duration exist for ESD and EFT threats). A transient pulse waveshape is defined as having a front time and a fall time. Front time is characterized by the length of time needed for the peak pulse current (I_p) to reach its peak value, as shown in Fig. 3, (a). The fall time is characterized as

the length of time needed for the peak pulse current to reach 50% of its peak value, as shown in Fig. 3, (b). This is often referred to as the pulse duration (t_d). The front time of the waveshape is important when selecting a package and laying out the trace on the printed circuit board. Placement of the TVS within the circuit/system for ESD and EFT transient events is important to minimize the overshoot voltage.

Figure 3: 8/20 μ s Pulse Waveshape



TESTING & PLACEMENT

Unfortunately, most TVS specifications do not provide the transient current ratings for fast rise time transient events, such as electrostatic discharge (ESD) and electrical fast transients (EFT). Both of these transients can present a significant threat to board level IC components. For instance, ESD can occur in the tens of thousands of volts within just a few nanoseconds. However, a TVS will clamp this voltage to an acceptable level with proper selection, placement, and connection on the printed circuit board. Protection is best determined by an in-circuit transient test, because of trace lead inductance.

Matching circuit parameters to TVS device parameters and complying to industry standards is only part of the story. In terms of effective protection and circuit performance, the placement of a TVS on the printed circuit board (PCB) can be critical. Typically, problems occur when the circuit/system is tested to a specific transient immunity standard and the TVS is found to be improperly placed (if it is there at all) on the PCB or ground contacts that are high in impedance. This can cause significant voltage differentials between data lines or ground points. Compliance testing a circuit/system design after all the components, layout circuitry, and interconnects have been established can be a costly mistake. A good rule of thumb is to review the circuit/system layout at designed frequencies to determine problem areas before they occur.

Again, compliance testing to industry immunity standards such as IEC, EN and ANSI is helpful in determining the types of transients the PCB may be affected by. It is also recommended that an EMI/RFI analysis be conducted before and after component placement and trace routing have been identified on the PCB.

Where is the best location for a TVS device? That is a good question. Transient threats at the I/O port interface are either tertiary lightning, internal switching, or ESD. TVS device placement is determined by the source of the transient threat, whether it be interior or exterior. For instance, a discrete TVS may be more appropriate for protection at the individual IC component when protecting against internally generated threats which are generally low level and very fast. Internal sources of these types of threats are attributed to high speed clocks, fast (digital) signals, and poor grounding, whereas external sources are linked to long signal lines and sometimes poor grounding.

EMF/RFI disturbances can also become a potential threat if the circuit is not

properly laid out for minimum noise pickup. As stated above, EMC sources have been attributed to high speed clocks, fast signals, long signal lines and poor grounding. Electromagnetic (EM) radiated voltages generally come from onboard loops in PCB traces. When these transient (noise) sources exceed the withstand level of the IC component, they can cause malfunctions in the circuit. For this type of situation, a TVS should be placed adjacent to the IC component.

When inadequate grounding is a concern, the placement of the TVS should always be in reference to a low impedance ground return path. This type of ground path is most likely to be used as the return path for the transient current. For example, common mode threats such as lightning and ESD, are referenced to low impedance ground whether it is a chassis or a PCB ground plane.

It is important to design a ground system (path) with a minimum number of discontinuities for reducing common mode radiation. In applications where there are both analog and digital signals without a common ground, it is recommended that a low voltage TVS device be used between two grounds to prevent significant voltage differentials between grounds. It is also recommended that, the TVS be a higher voltage than the operating voltage of the two signals.

Placing a TVS at the card edge aids in keeping both the input and output lead traces to a minimum. As stated earlier, placement at the card edge will also minimize the introduction of radiated emissions onto the PCB during a transient event. This is also a good location to provide both I/O port and power bus protection. The number of I/O ports that need to be protected will determine the TVS device package, i.e., single components or an array of devices. For example, a single device is recommended for a single I/O port, when a single IC component requires protection or when a layout of signal trace lines is best for individual line protection. An array package is usually recommended for multiple I/O port protection and for its cost effectiveness. It is essential that a low impedance ground be used for the return path of both the power bus and I/O port protection.

SUMMARY

There is no text book procedure that provides a step by step solution to bulletproofing a circuit/system design - the transient environment is too application dependent. There are many variables that an engineer must take into consideration throughout the design-in process. The circuit/system has certain performance and immunity standards that must be complied with. Circuit operating parameters such as signal operating voltage and frequency need to be established in order to insure proper selection of the TVS device. Lastly, the TVS must be appropriately placed within the circuit/system. I/O port protection for either balanced or unbalanced line configurations does not have to be confusing. The best TVS device is one that meets the above design criteria of the application and the environmental conditions. With some basic knowledge about the application and the TVS device parameters, a cost effective solution can be attained.

The following are some general guidelines that will reduce the trial and error process for TVS selection.

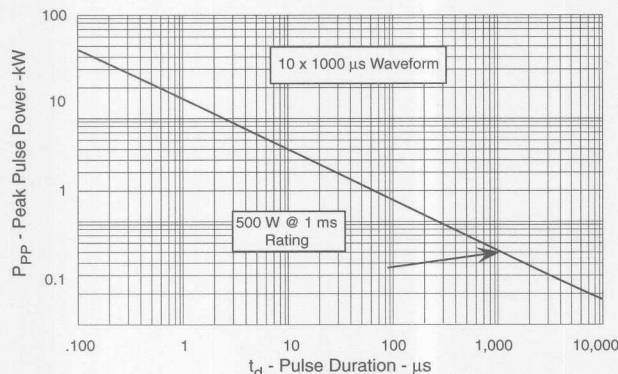
1. TVS device capacitance should be consistent with the frequency (data rate) of operation.
2. Frequency response or insertion loss should be less than 1 db at operating frequency.
3. The peak pulse transient current should be less than the maximum handling current of a TVS.
4. The circuit operating voltage should be less than the stand-off voltage of a TVS.
5. Furthermore, keep in mind that circuit performance and transient immunity compliance must be a part of the design cycle and test procedures before systems are released for production.

Maximum Peak Pulse Current (I_{pp}) vs Pulse Duration (t_d) for TVS Devices

by
David W. Hutchins
ProTek Devices, 1997

Silicon Avalanche Junction Transient Voltage Suppressors (TVS)¹ are categorized according to their maximum peak pulse power rating (P_{pp}) for a specific pulse waveshape, i.e., 10/1000 μ s or 8/20 μ s. Normally, manufacturers² indicate the power rating of a particular TVS as a curve representing a derating in power (P_{pp}) over a given pulse duration (t_d). Fig. 1 shows the typical power curve of a SA15A with a peak pulse power (P_{pp}) rating of 500 Watts at the 1 millisecond duration.

Figure 1: Peak Pulse Power vs Pulse Duration for the SA15A



A pulse duration (t_d) is defined as the front time plus its fall time. Front time is characterized by the length of time needed for the peak pulse current (I_{pp}) to reach its peak value as shown in Figure 2, (a). The fall time is characterized as the length of time needed for the peak pulse current to reach 50% of its peak value as shown in Figure 2, (b).

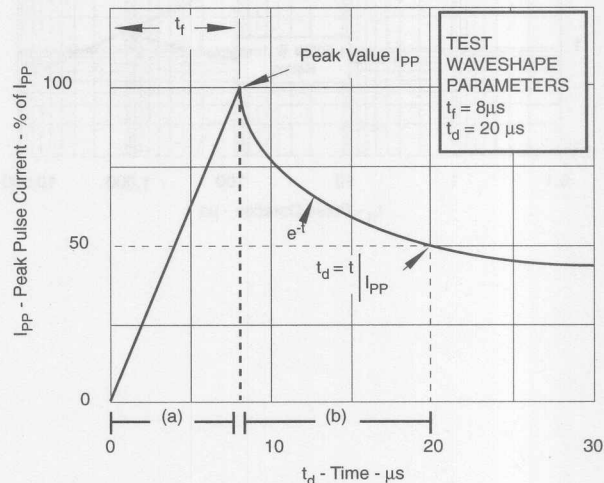
The maximum peak pulse current rating (I_{pp}) of a TVS device parallels the peak pulse power curve. The maximum peak pulse power (P_{pp}) is equal to the maximum clamping voltage (V_C) times the maximum peak pulse current (I_{pp}) where the maximum clamping voltage is considered a constant, independent of time. Typically, the maximum clamping voltage is called a failure threshold voltage for a given silicon P/N junction diode. If we consider this voltage a constant over time then the power curve also represents the current rating over time.

There are two methods that can be used to calculate the maximum peak pulse current (I_{pp}) of a TVS at any given pulse duration if not already provided by the manufacturer³. Both methods use the power curve.

METHOD ONE

The first method used to calculate the maximum current rating of a specific device type at a given pulse duration, is by using the slope of the power curve. To determine the slope of the power curve per decade, that is from 1000 μ s to 100 μ s, find the ratio for that given decade. For example, the SA15A, as shown in Figure 1, has a peak pulse power rating of 1500 W at 100 μ s and 500 W at 1000 μ s making the slope 3 for that decade.

Figure 2: 8/20 μ s Pulse Waveshape



The second step in the calculation is to multiply the slope by the device's maximum peak pulse current (I_{pp}) rating. For example, SA15A has a maximum peak pulse current rating of 24.4 A for a pulse duration of 1000 μ s⁴. Given the peak pulse current rating for a specific pulse duration such as 1000 μ s, the peak pulse current for a shorter pulse duration of 100 μ s can be calculated. If we multiply the 24.4 A by a ratio of 3, then the maximum peak pulse current rating for 100 μ s is 68.32 A.

Another example is the 1.5KE18A power curve shown in Figure 3. The slope of power curve from 1000 μ s to 100 μ s, has a ratio of 2.8 times per decade. If we multiply the maximum peak pulse current rating of 60 A at a pulse duration of 1000 μ s by the ratio of three, the maximum peak pulse current for 100 μ s is 168 A.

METHOD TWO

Unlike the first method, method two does not use the slope of the peak pulse power curve. To determine the peak pulse current rating (I_{pp}) at a given pulse duration, divide the peak pulse power rating (P_{pp}) by the maximum clamping voltage (V_C). For example, the SA15A has a maximum clamping voltage of 20.6 V. At the 100 μ s pulse duration, the SA15A has a peak pulse power rating of approximately 1400 W, as shown in Figure 1. If we divide 1400 W by 20.6 V, the calculated maximum peak pulse current rating (I_{pp}) is 67.96 A⁵.

Again, the 1.5KE18A has a maximum clamping voltage of 25.0 V. At the 100 μ s pulse duration, the 1.5KE18A has a peak pulse power rating of approximately 4200 W, as shown in Figure 3. If we divide 4200 W by 25.0 V, the calculated maximum peak pulse current rating is 168 A.

¹ The new IEC term for a silicon avalanche junction TVS device is Avalanche Break-down Diode (ABD).

² In addition to the power curve, the manufacturer often provides the maximum clamping voltage (V_C), the maximum peak pulse current (I_{pp}) and pulse waveshape.

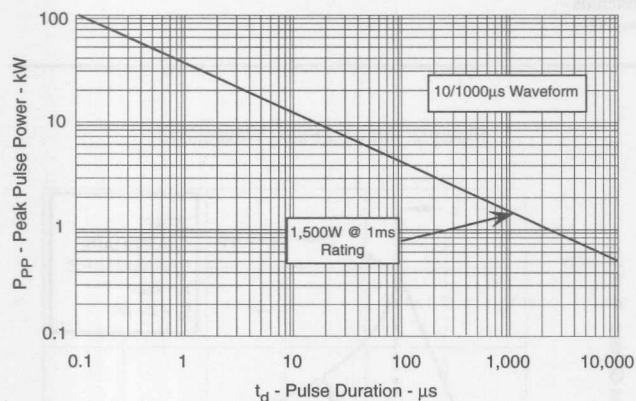
³ Some data sheets do not provide this maximum rating. Therefore, it is important to contact the manufacturer directly for more information regarding the electrical characteristics of a particular device type or series.

⁴ The maximum peak pulse current given for each example was taken from a ProTek Devices databook for the following part numbers: SA15A and 1.5KE18A.

⁵ The calculated I_{pp} rating using method one is 68.32 A; which is very close in value to the I_{pp} rating of 67.96 calculated by using method two.

It is important to note, that for purposes of calculating the maximum peak pulse current rating for smaller pulse durations, it is recommended that the maximum clamping voltage be increased by only 5% per decade (1000 μ s to 100 μ s) in order to achieve a more accurate rating.

Figure 3: Peak Pulse Power vs Pulse Duration for the 1.5KE18A



As the pulse duration gets smaller, such as less than 0.100 μ s, the apparent failure threshold voltage become larger for two reasons. First, the higher peak pulse currents cause the voltage to increase due to the series resistance of the silicon material. Second, the temperature of the device will increase due to the high current causing the voltage to be somewhat higher in proportion to the temperature coefficient of the voltage type. Typically, the increase in clamping voltage attributed to these two causes is about 5% to 10% increase per decade.

SUMMARY

There are no exact equations for calculating the maximum peak pulse current of a TVS device for various pulse widths (duration t_p). An equation would be very complex involving the silicon material, packaging, and mounting conditions as well as chip resistance and the thermal effects at higher pulse durations. However, a reasonable approximation of the maximum peak pulse current rating (I_{pp}) can be obtained by using either of the above two methods



TVS Voltage Characteristics for an Electrostatic Discharge Pulse

by
David W. Hutchins
ProTek Devices, 1998

The most significant transient threat to IC components connected directly to I/O ports is Electrostatic discharge (ESD). Typical sources of ESD include Human Body Model (HBM), Machine Model (MM), and Charge-Device Model (CDM). The difference between these sources exist in their transient voltage (kilovolts) and peak current (10s of amperes) levels. For instance, a Human Body Model-ESD transient can occur in excess of 40 kilovolts with a current greater than 80 amperes. Any one of these sources can cause an upset in performance or degradation to a sensitive IC component. Generally, transient currents affect the performance of the IC component; whereas excessive voltage transients tend to damage the device. Therefore, it is important to provide some type of protection to clamp the incident voltage and divert the transient current away from the IC component.

Transient voltage suppressors (TVS) are universally known for effectively clamping voltage levels well within the withstand limits of the IC component. However, the withstand limits of an IC component are often unknown due to the lack of published information from the IC manufacturer. In fact, IC components can withstand a higher voltage level than their continuous operating voltage. Again, this information is often unavailable because IC chip design is constantly changing. Many IC component manufacturers do not identify this voltage parameter, but only caution the designer about the steady state condition. Thus, for circuit design engineers, it can be a trial and error process in determining the IC component's withstand levels, which are dependent upon the pulse duration (pulse waveshape) of the transient threat.

TVS DEVICE CHARACTERISTICS

The TVS device parameters that affect clamping voltage are on-resistance, temperature, and packaging. The on-resistance of a low voltage device (less than 30 volts) is generally less than 500 milliohms. Higher voltages can have an on-resistance from 2 to 4 ohms. Temperature effects include junction heating due to high transient currents and a temperature coefficient of the breakdown (avalanche) voltage. In addition, TVS devices with a breakdown voltage of 5 volts or higher will always have a positive temperature coefficient.

Depending upon the transient current values, temperature effects should be taken into account with standard test waveshapes, such as 8/20 ms and 10/1000 ms, when specifying a maximum clamping voltage of a device. For pulse waveshapes in the nanosecond region, additional criteria must be considered. Internal packaging designs and lengths of lead wires will have an effect on both the overshoot voltage (due to transient dv/dt characteristics) and the actual clamping of the TVS device (due to the transient di/dt characteristics) to a lesser degree.

Overshoot voltage is defined as the voltage that appears on the leading edge of the voltage waveform. This characteristic is attributed to the internal package design which has some finite inductance and the rate of a fast rise time pulse. It is possible to measure the overshoot voltage with a gigahertz oscilloscope. An overshoot voltage is generally clamped within 10 to 20 nanoseconds. Peak voltage measurements beyond this time are the result of the decaying peak pulse current of an ESD event. Although overshoot voltage can vary from test to test as a result of package design, the clamping voltage is a constant value¹. Clamping voltage is characteristic of the TVS device's response to the peak pulse current, pulse duration, and on-resistance.

TEST RESULTS

A Schafner ESD gun, type NSG432, with a discharge voltage capability of 25 kilovolts was used for the following tests. The ESD simulator generates a Human Body Model pulse waveshape of less than 1/60 ns. It appears that the gun is designed to have a fixed voltage rise pulse independent of the charge voltage. The two devices tested were an LCD05C and an SMDA05LCC. Their electrical specifications are shown in Table 1.

Figures 1 and 2 represent the voltage response of an LCD05C for a 10 kilovolt ESD pulse duration of 1/30 ns. Likewise, Figures 3 and 4 represent the voltage response of an LCD05C for a 20 kilovolt ESD pulse duration of 1/30 ns. Figures 1 and 3 take a closer look at the overshoot voltage of the TVS at 5.0 nanosecond per division. From these two figures, it appears that the rate of rise is similar for the 10 kilovolt and 20 kilovolt pulse. They are similar as a result of the fixed rate of rise of the ESD pulse, test equipment, and the fixed package lead inductance but not the turn on time of the TVS. Generally, the turn on time of a TVS is less than 1 ns.

Figures 2 and 4 shows the overshoot voltage, clamping voltage, and the breakdown voltage of the TVS at 50.0 nanoseconds per division. As expected, the 20 kilovolt ESD pulse has a higher current value and a longer pulse duration than the 10 kilovolt ESD pulse. Although the waveshapes are somewhat different, the clamping voltage appears to be similar due to the design of the TVS device. Also, both devices show breakdown voltages of 6.9 volts due to the extended trailing edge of the ESD pulse. The dotted line, shown in Figures 2 and 4, represents the actual breakdown voltage of the TVS device when measured at 1 milliamperes.

The second TVS device measured was the SMDA05LCC. Figures 5 and 6 show the voltage characteristics of the above device with an ESD pulse duration of 1/30 ns at 20 kilovolts. Figure 5 represents the overshoot voltage of the device at 5.0 nanoseconds per division and the resulting effects of package lead inductance. The higher voltage is attributed to a much longer

Table1: Electrical Specifications for Transient Voltage Suppressor (TVS) Arrays

PROTEK PART NUMBER	PEAK PULSE POWER RATING (8/20 μ S) P_{PP} WATTS	STAND-OFF VOLTAGE V_{WM} VOLTS	LEAKAGE CURRENT @ V_{WM} I_D μ A	BREAKDOWN VOLTAGE @ 1 mA $V_{(BR)}$ VOLTS	CLAMPING VOLTAGE V_C VOLTS	CLAMPING VOLTAGE @ I_{PP} V_C VOLTS	MAXIMUM PEAK PULSE CURRENT I_{PP} AMPS
SMDA05LCC	300	5.0	100	6.0	12.5 @ 5 A	14	26
LCA05C	500	5.0	100	6.0	12.5 @ 10 A	22	40

¹ Clamping voltage may vary depending on temperature.

wire length due to the multiple bonds. The reflected signal responses are due to a mismatch in device equipment impedance. Figure 6 represents the overshoot voltage, clamping voltage, and the breakdown voltage at 50.0 nanoseconds per division. As a result of the smaller diode junction in comparison to the LCD05C, the SMDA05LCC has a higher clamping voltage during the ESD event. Within 200 nanoseconds the device breaks down to another voltage level simulating a reduction in the ESD current.

SUMMARY

As the results suggest, the device characteristics display three significant voltage levels: overshoot voltage, clamping voltage, and breakdown voltage. Most importantly, it is the clamping voltage that provides the level of protection for the IC component. Transient voltage suppressors are effective in clamping voltage levels well within the withstand limits of the IC component. Currently, TVS devices are successfully being used in I/O port applications. These devices can prevent IC component failure and malfunctions caused by ESD pulses in excess of 20 kilovolts.

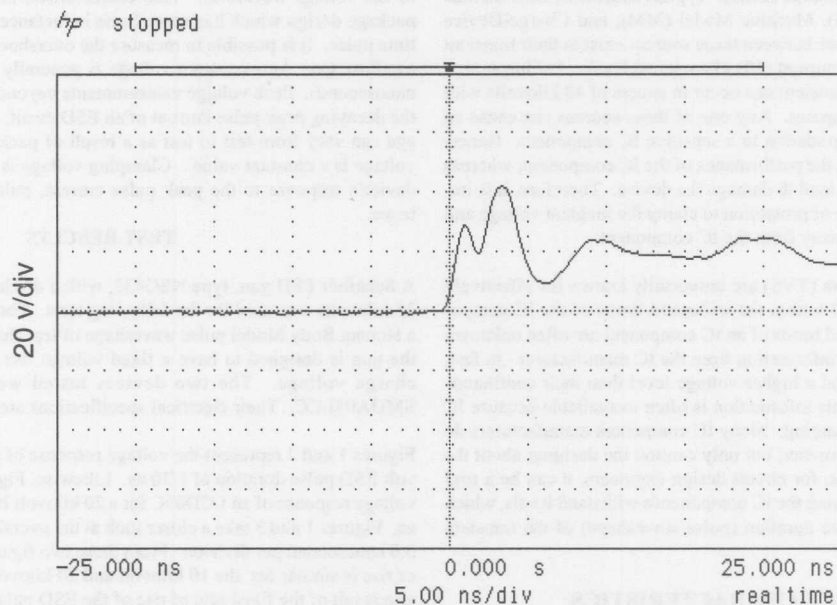


Figure 1
Overshoot & Clamping Voltage of LCA05C
ESD Test Pulse: 10 kV, 1/30 ns (waveshape), Peak Voltage: 38 V, 3 ns

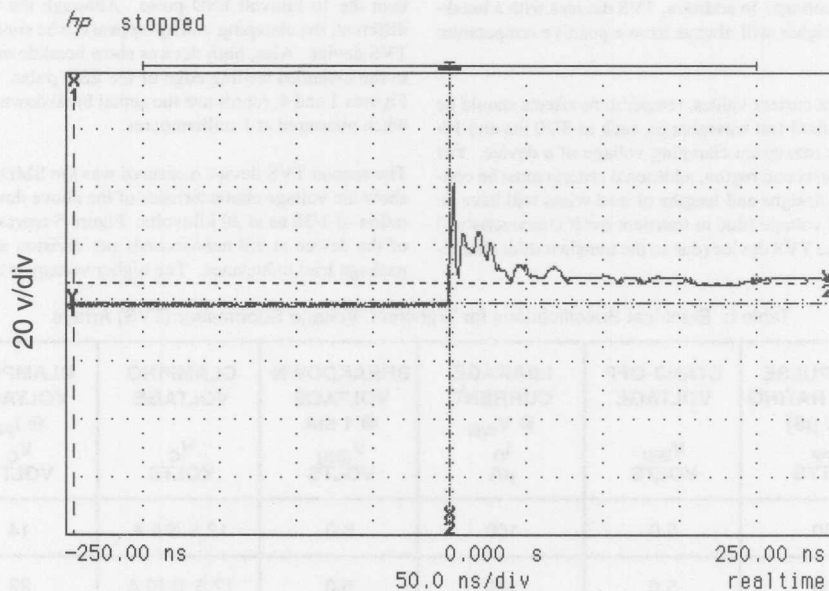


Figure 2
Overshoot & Clamping Voltage of LCA05C, ESD Test Pulse: 10 kV, 1/30 ns (waveshape)
(----- is a 6.9 volt marker), Peak Voltage: 38 V, < 5 ns



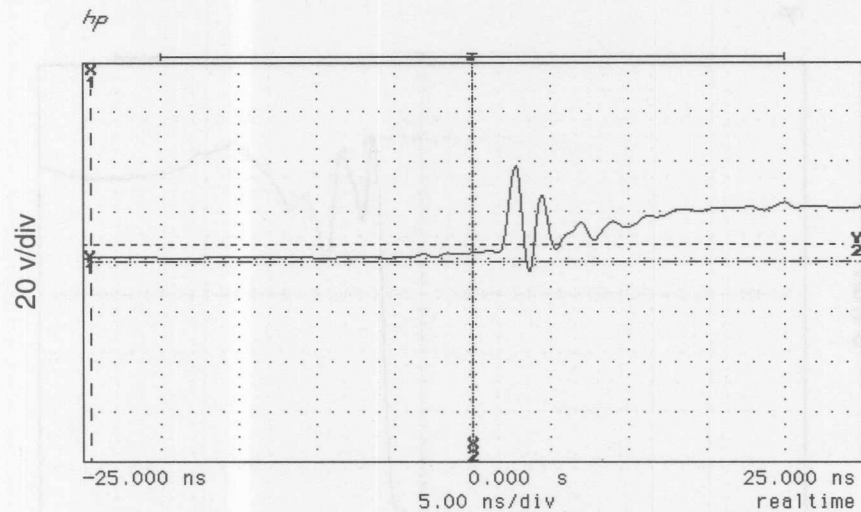


Figure 3
Overshoot & Clamping Voltage of LCA05C, ESD Test Pulse: 20 kV, 1/30 ns (waveshape)
(----- is a 6.9 volt marker), Peak Voltage: 38 V, 3 ns

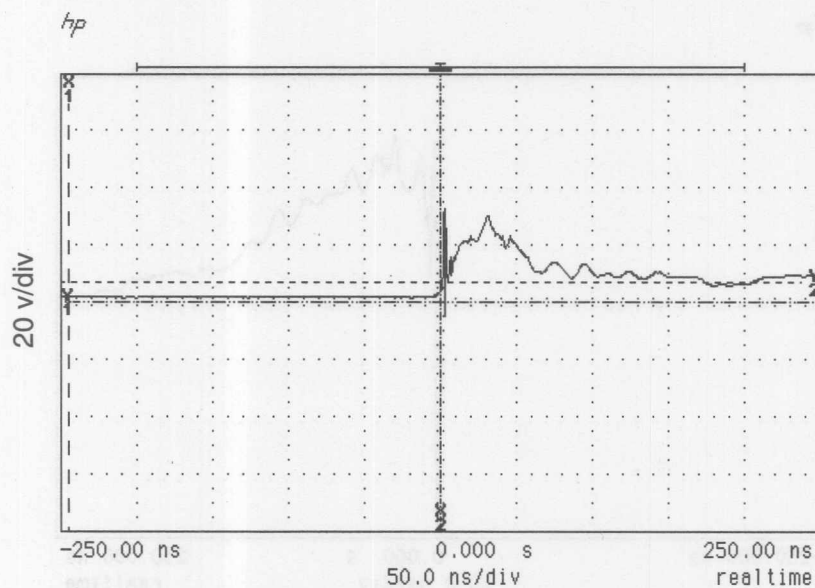


Figure 4
Overshoot & Clamping Voltage of LCA05C, ESD Test Pulse: 20 kV, 1/30 ns (waveshape)
(----- is a 6.9 volt marker), Peak Voltage: 32.5 V, < 5 ns

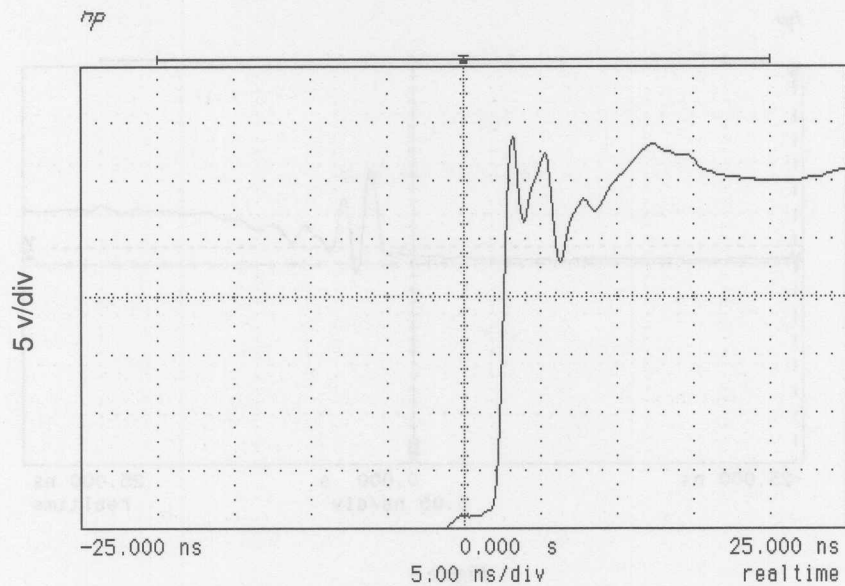


Figure 5
Overshoot & Clamping Voltage of SMDA05LCC,
ESD Test Pulse: 20 kV, 1/30 ns (waveshape), Peak Voltage: 33.7 V, 3 ns

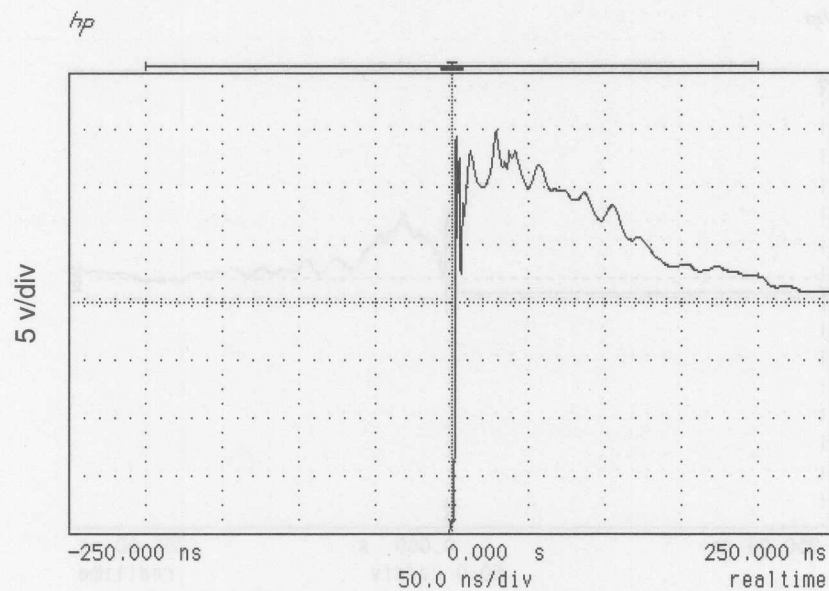


Figure 6
Overshoot & Clamping Voltage of SMDA05LCC
ESD Test Pulse: 20 kV, 1/30 ns (waveshape), Peak Voltage: 34.8 V, < 5 ns

IEC 1000-4 Standard Transient Immunity Requirements

by
David W. Hutchins
ProTek Devices

Electromagnetic Compatibility (EMC) has long been accepted as a term to describe the control of electromagnetic interference (EMI). Formerly, the exclusive components of EMC were radiated and conducted emissions. Today, EMC goes beyond the effects of radiated and conducted emissions to include transient threats such as lightning, switching transients and electrostatic discharge (ESD).

In the mid 1980s, the International Electrotechnical Commission (IEC) adopted the EMC requirements developed by the European Committee for Electrotechnical Standardization (CENELEC). These worldwide standards, published in a set of three documents known as the IEC 1000-4 (formerly IEC 801) requirements, provided the user with emission and immunity requirements for equipment/systems, as well as step-by-step procedures.

Because equipment/ systems must be able to operate after being exposed to a variety of electromagnetic disturbance. Proof of equipment/system compliance in the international market can be demonstrated by meeting all the requirements of a given IEC document.

The IEC 1000-4 requirements define three transient phenomena:

1. Electrostatic Discharge (ESD): IEC 1000-4-2
2. Electrically Fast Transients (EFT): IEC 1000-4-4
3. Surge Lightning: IEC 1000-4-5

Table 1 provides a brief overview of the above documents with reference to the environmental threat, waveform, and transient characteristics¹.

In addition to describing the threat source, the IEC 1000-4 documents identified various transient severity levels or classes depending upon the exposure of the equipment/system to protected or unprotected environments. Tables 2 through 4 are open circuit voltage and short circuit voltage conditions extracted from each of the IEC 1000-4 documents².

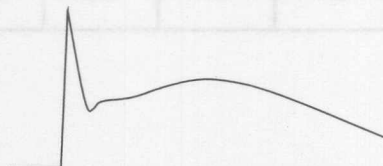
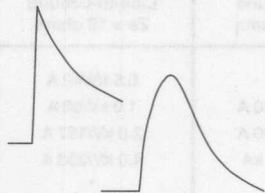
Table 2 shows the severity levels for an ESD generator. The maximum peak current level is 30 amperes for a contact discharge ESD voltage of 8 kilovolts.

Table 3 shows the severity levels for an EFT generator. Transients represented in this table are from arcing contacts associated with the opening of relays and switches. Due to the nature of the source, both data and power lines are affected. IEC 1000-4 is the first document that has defined a transient threat condition for both data and power lines from the same threat source. Energy can be induced or directly injected into either of the equipment/system lines depending upon the interfacing layout.

Table 4 shows the threat levels for the open circuit voltage condition for an 1.2/50 μ s waveform and the short circuit current for an 8/20 μ s waveform.

These two waveforms are characteristic of a single generator representing a different pulse for the open circuit voltage and short circuit current conditions.

Table 1: Transient Immunity Standards

INTERNATIONAL STANDARD	ENVIRONMENTAL THREAT	TRANSIENT CHARACTERISTICS	TEST WAVEFORM
1000-4-2	ESD	Super Fast < 1 ns Low Energy	
1000-4-4	EFT	Fast 5 ns Medium Energy (per burst)	
1000-4-5	Surge	Surge 10-700 μ s High Energy	

¹ Boxleiter, Warren, "The Triple Threat of Pulsed EMI", *Test & Measurement World*, May 1993.

² Neil, Don and Clark, O. Melville, "Electrical-Transient Immunity: A Growing Imperative for System Design", *Electronic Design*, January 1992.

This is often referred to as a combination wave and is characteristic of lightning transient threat test conditions.

Table 5 shows the ProTek part numbers that can be used for protection in a data line application. The blank spots are an indication that a higher powered component is required. For power supply applications, higher power is required. Discrete components or an assembly of devices may be needed depending upon the location of the TVS and point of entry. *For more information regarding device selection and ESD/EFT (IEC 1000-4-2 & -4) refer to page 2-2 in this databook.*

The European Community (EC) has taken the necessary steps to make these requirements mandatory. Initially, the EMC Directive, 89/336/EEC, required equipment that was not under other similar document requirements to be in compliance with IEC 1000-4.

For the EC, the exact requirements are documented in their Euronorm standard EN50082-1. Within this document are the requirements of IEC 1000-4. Other countries adopting the IEC requirements have their own nomenclature. However, at the printing of this application note, these documents are not known.

Table 2: IEC 1000-4-2 Waveform Parameters

	LEVEL			
	1	2	3	4
INDICATED VOLTAGE	2 kV	4 kV	6 kV	8 kV
FIRST PEAK CONTACT DISCHARGE ($\pm 10\%$)	7.5 A	15.0 A	22.5 A	30.0 A
RISETIME t_r WITH DISCHARGE SWITCH	0.07 - 1 ns	0.07 - 1 ns	0.07 - 1 ns	0.07 - 1 ns
CURRENT @ 30 ns	4 A	8 A	12A	16 A
CURRENT @ 30 ns	2 A	4A	6A	8 A

Table 3: IEC 1000-4-4 Waveform Parameters

PEAK AMPLITUDES	LEVEL			
	1	2	3	4
ON POWER SUPPLY PORT, PE, V_{OC}^*	0.5 kV	1.0 kV	2.0 kV	4.0 kV
ON POWER SUPPLY PORT PE, I_{SC}^*	10 A	20 A	40 A	80 A
ON I/O SIGNAL DATA & CONTROL LINES V_{OC}^*	0.25 kV	0.5 kV	1.0 kV	2.0 kV
ON I/O SIGNAL DATA & CONTROL LINES I_{SC}^*	5 A	10 A	20A	40 A

* Depends on the class of the local power supply system.

Table 4: IEC 1000-4-5 Waveform Parameters

CLASS	POWER SUPPLY		UNSYMMETRICAL LINES (LONG DISTANCE BUS)		SYMMETRICAL LINES	DATA BUS (SHORT DISTANCE)
	COUPLING MODE		COUPLING MODE		COUPLING MODE	
	Line-to-Line $Z_s = 2$ ohms	Line-to-Ground $Z_s = 12$ ohms	Line-to-Line $Z_s = 42$ ohms	Line-to-Ground $Z_s = 42$ ohms	Line-to-Ground $Z_s = 42$ ohms	Line-to-Ground $Z_s = 42$ ohms
1	—	0.5 kV/42 A	—	0.5 kV/12 A	1.0 kV/24 A	—
2	0.5 kV/250 A	1.0 kV/83 A	0.5 kV/12 A	1.0 kV/24 A	1.0 kV/24 A	0.5 kV/12 A
3	1.0 kV/500 A	2.0 kV/167 A	1.0 kV/ 24 A	2.0 kV/48 A	2.0 kV/28 A	—
4	2.0 kV/1 kA	4.0 kV/333 A	2.0 kV/48 A	4.0 kV/95 A	—	—
5	*	*	2.0 kV/48 A	4.0 kV/95 A	4.0 kV/95 A	—

* Depends on the class of the local power supply system.

Peak current values are short circuit currents with a 8/20 μ s waveform, based upon the Z_s values indicated in each column.



**Table 5: Product Selection Guide for IEC 1000-4-5
(Data Lines Only)**

CLASS	UNBALANCED OPERATED CIRCUITS/LINES (LBD Coupling Mode)		BALANCED OPERATED CIRCUITS/LINES (Coupling Mode)
	Line-to-Line	Line-to-Ground	Line-to-Ground
1		DA05, 12, 15 DLZ-5, 8, 13, 19 LCA05C, 12C, 15C LCD05C, 12C, 15C PLC01-6 PLC03-6 PLCDA03, 05 PSLC03, 05 PSOT03C PSOT03LC SMDA05LCC, 08LCC, 12LCC SM8LC05 SM14M05 SM16LC05C, 08C, 12C	DA05, 12 DLZ-5, 8, 13 LCA05C, 12C LCD05C, 12C PLC01-6 PLC03-6 PLCDA03, 05 PSLC03, 05 PSOT03C PSOT03LC SMDA05LCC, 08LCC, 12LCC SM8LC05 SM14M05 SM16LC05C, 08C, 12C
2	DA05, 12, 15 DLZ-5, 8, 13, 19 LCA05C, 12C, 15C LCD05C, 12C, 15C PLC01-6 PLC03-6 PLCDA03 PSLC03, 05 PSOT03C PSOT03LC SMP6LC05-2P SM8LC05 SM14M05 SM16LC05, 08, 12 VS10P05C, 8C, 12C	DA05, 12 DLZ-5, 8, 13 LCA05C, 12C LCD05C, 12C PLC01-6 PLC03-6 PLCDA03 PSOT03C PSOT03LC SMDA05LCC, 08LCC SMP6LC05-2P, 12-2P SM8LC05 SM14M05 SM16LC05, 08 VS10P05C, 8C, 12C	DA05, 12 DLZ-5, 8, 13 LCA05C, 12C LCD05C, 12C PLC01-6 PLC03-6 PLCDA03 PSOT03C PSOT03LC SMDA05LCC, 08LCC SMP6LC05-2P, 12-2P SM8LC05 SM14M05 SM16LC05C, 08C
3	DA05 DLZ- 5, 8 LCA05C LCD05C PLC01-6 PLC03-6 SMP6LC05-2P SM8LC05 SM14M05 VS10P05, 05C, 05LC	PLC01-6 PLC03-6 SMP6LC05-2P VS10P05C, 05C, 05LC	DA05 DLZ-5, 8 LCA05C LCD05C PLC01-6 PLC03-6 SMP6LC05-2P SM8LC05 SM14M05
4	PLC01-6 VSB10P05, 05C, 05LC	PLC01-6	PLC01-6

RTCA/DO-160 Product Selection

by
David W. Hutchins
ProTek Devices, 1994

The RTCA/DO-160 document is a system level specification for commercial aircraft. Within this document, there are specific environmental conditions and test procedures for certification of airborne equipment. In particular, Section 22 (Lightning Induced Transient Susceptibility) deals with the internal transient threats to critical aircraft systems/equipment¹. This section was set up by DO-160 to help the equipment manufacturer categorize and test their equipment for installation within specific types of aircraft with reference to their location.

Section 22 defines specific test conditions for two types of aircraft: Metallic and Non-metallic (Composite). Testing is further defined by waveform sets, type of test and test levels.

1. Waveform sets are one or two sets of transient waveforms that describe the voltage or current pulse of a transient threat.
2. The types of tests used for testing critical equipment are two specific test methods: Pin Injection and Cable Bundle.
3. Test levels are open circuit voltage and short circuit current test conditions that are defined by the location of the equipment within the aircraft.

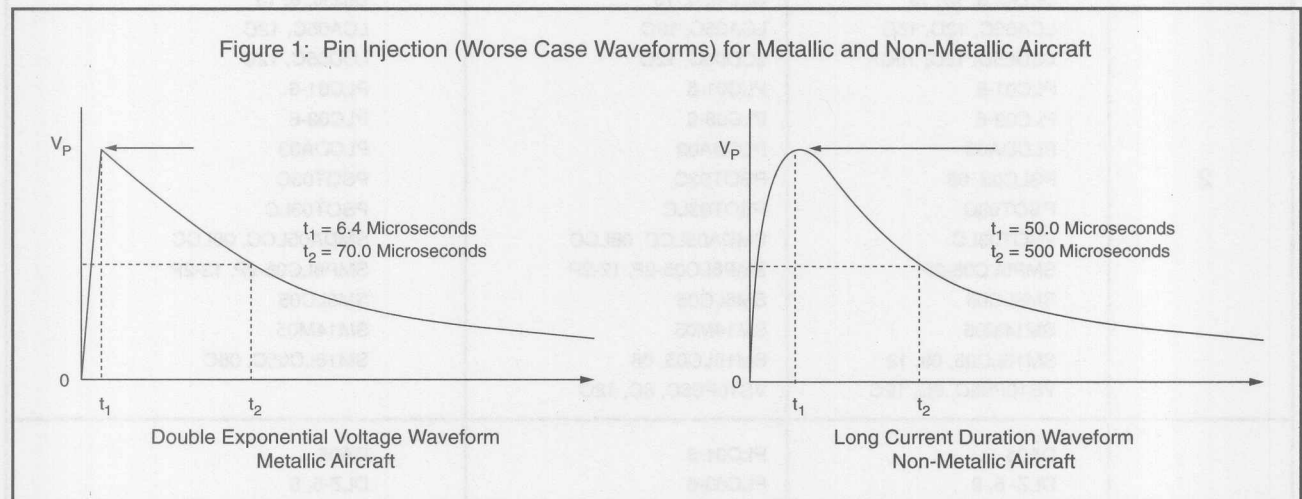
However, in order to adequately reduce the transient threat, some type of protection element is required at the equipment interface.

Although the airframe manufacturer is responsible for identification of the transient threat conditions for their equipment, it is up to the equipment supplier to assure that the system is protected. Several methods can be used to comply with the transient control levels (TCL). One is to design a system with internal components that are above the equipment transient susceptibility level. Another, is to provide sufficient filtering so that nothing will get through. However, these are costly solutions and add weight to the overall system/equipment.

A preferred alternative is the use of a transient voltage suppressor (TVS) at all input ports to the equipment. After a system/equipment has been defined in terms of the waveform set and test level, the next step is to select a TVS. Device selection should be concerned with the longest duration (waveform) and highest current exposure (test level) of the transient threat. Figure 1 shows the worst case test waveforms for the metallic and non-metallic aircraft for pin injection.

For a metallic aircraft, the critical waveform is defined as a Double Exponential Voltage Waveform (6.4/70 μ s). For non-metallic aircraft the critical waveform is defined as the Long Duration Current Waveform (50/500 μ s). When selecting

Figure 1: Pin Injection (Worse Case Waveforms) for Metallic and Non-Metallic Aircraft



All of these specifications are coordinated by a category designator. For example, a piece of equipment must be categorized according to a waveform set and test levels for both pin injection or cable bundle testing.²

Lightning can enter the aircraft causing physical damage, loss of data or change the states of sensitive control equipment. This is usually the result of high current transients flowing in the distributed wiring causing a voltage difference between circuits. This can also be a result of an electromagnetic field inducing a voltage transient into an adjacent wire. Shielding and the application of good engineering practices to assure continued system performance is essential.

a TVS, it is the pulse duration, 70 μ s and 500 μ s that is used to obtain a TVS power rating. An example of a Peak Pulse Power vs Pulse Duration curve is shown in Figure 2. From this curve, the power rating for a particular TVS device is about 50 kilowatts for 70 μ s and 10 kW for 500 μ s. The peak current rating for any given TVS voltage type can be determined by dividing the power rating by the maximum clamping voltage. For example the maximum clamping voltage for a 94 volt TVS, with a peak pulse current at 70 μ s is 532 Amps and at 500 μ s it is 191 Amps. It is important to note that these current values may be less than the short circuit current levels of the threat conditions given in Section 22 of DO-160C.

¹ The latest revision for the RTCA/DO-160 document, Section 22 is change notice 2 of DO-160C.

All figures and tables are in reference to this revision.

² Pin Injection test conditions are more clearly defined in terms of the applied threat levels to the pins, therefore, this application note will only address these tests.



Figure 2: Peak Pulse Power vs Pulse Time

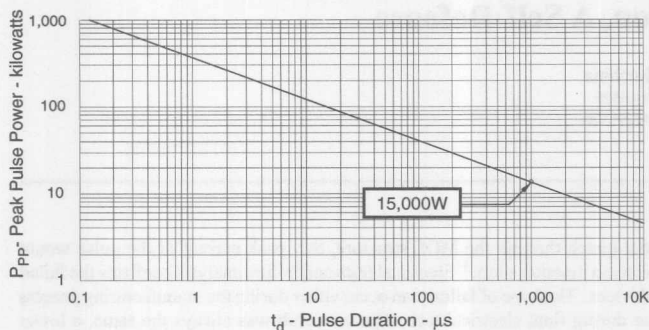


Table 1 shows the transient threat level conditions for Pin Injection. Note that for each level, there are values for both voltage and current. However, it is the combination of the current level and pulse duration that dictates the worst case

Table 1: Test Levels for Pin Injection

LEVELS	WAVEFORMS			
	4 @ 6.4/70 μ s		5 @ 50/500 μ s	
	V _C VOLTS	I _{SC} AMPS	V _C VOLTS	I _{SC} AMPS
1	50	10	50	50
2	125	25	125	50
3	300	60	300	60
4	750	750	750	750
5	1,600	320	1,600	320

condition. As stated earlier, only the conditions for Pin Injection tests are given here as it represents the actual worse case test conditions between this method and the Cable Bundle conditions.

Two types of levels of Pin Injection testing are included in Tables 2 and 3. Table 3 is for conventional Metallic aircraft and Table 4 is for aircraft manufactured using composite materials (Non-Metallic).

Table 2: Pin Injection Test Level Product Matrix for Metallic Aircraft

SERIES	POWER	TEST LEVELS			
		@ 5V	@ 12V	@ 28V	@ 48V
A	280 W	1 - 2	1	—	—
B	4 kW	1 - 5	1 - 4	1 - 3	1 - 2
C	8 kW	—	1 - 5	1 - 4	1 - 3
D	20 kW	—	—	1 - 5	1 - 4
E	40 kW	—	—	—	1 - 5

Note: "Series" denotes a four line TVS array with the power rating shown under the "Power" heading. "Power" is based upon a 6.4/ 70 μ s waveform.

Both power and data and signal input ports require a particular level of protection depending upon the location. Coordination of both the power and data lines is necessary with reference to a common point ground (bonding). This will prevent any potential differences occurring between the various input lines and prevent ground bounce problems. For the purpose of this type application, a TVS array product was selected consisting of four discrete devices within a single package. Most systems will have multiple input voltage ports.

The single-in-line SIP package takes less space and can be located on a printed circuit board just after the connector assembly, affording protection of multiple input lines. Figure 3 shows the package outline of a four line array product. This type of package can be manufactured with various power ratings without changing the outline dimensions.

Table 3: Pin Injection Test Level Product Matrix for Non-Metallic Aircraft

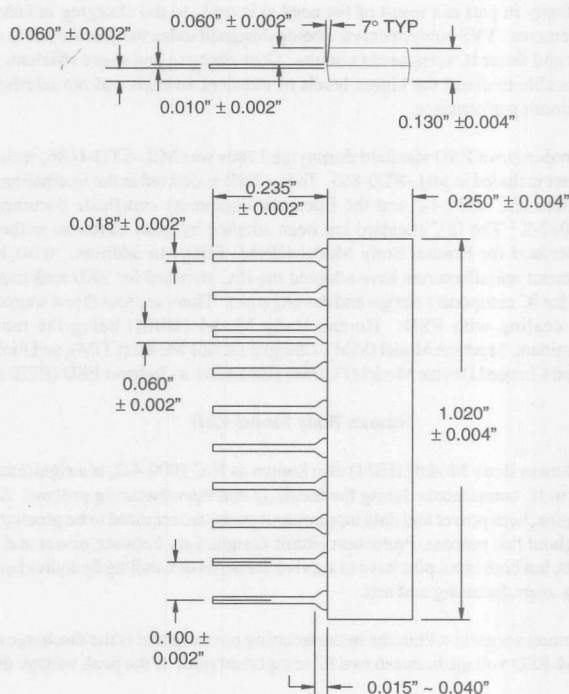
SERIES	POWER	TEST LEVELS			
		@ 5V	@ 12V	@ 28V	@ 48V
B	900 W	1	—	—	—
C	2.4 kW	1 - 2	1	—	—
D	4.8 kW	1 - 3	1 - 2	1	—
E	8 kW	1 - 4	1 - 3	1 - 2	1

Note: "Series" denotes a four line TVS array with the power rating shown under the "Power" heading. "Power" is based upon a 50/500 μ s waveform.

Tables 3 and 4 can be used to aid in the selection of a this type of TVS device (4 line SIP). For example a 28 V power bus must be protected to a test level of 3 for a metallic aircraft. From Table 3, the series type is B. A description of the product at this point is B28. From this information a more complete description of the product can be obtained³.

Lightning induced transient susceptibility is a serious issue to all commercial aircraft manufacturers. Certification of all airborne equipment must meet the system level specifications of the RTCA/DO-160 document. A TVS device is a cost effective alternative to the heavy components and filtering that are needed in order to protect the aircraft to these specifications. In particular the 4 line SIP is ideal for this type of application.

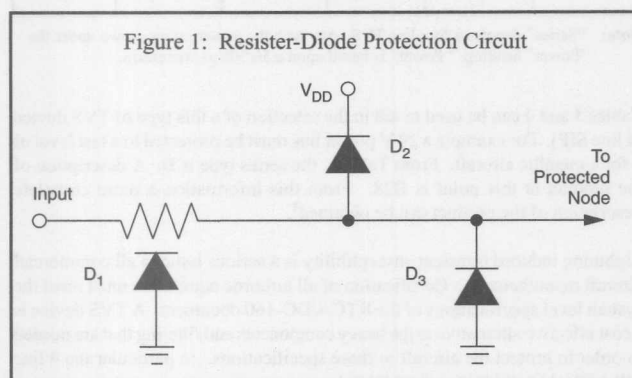
Figure 3: Four Line Array In SIP Package



"On-Chip" Protection, A Self-Defense

by
David W. Hutchins
ProTek Devices, 1996

As a result of the devastating effects of Electrostatic Discharge and Radiated Emissions, "On-Chip" protection structures have been an integral part of the development and manufacturing process of CMOS/NMOS IC Components. A simple resistor/diode structure as shown in Figure 1, played a key role in the early chip designs for ESD protection. Although the threats have not changed, protection networks have evolved over the years in their complexity and use of additional integrated elements. Some of these component elements are



polysilicon resistors, parasitic diodes, bipolar transistors, P or N channel FETs and P or N MOS FETs. Newer structures are using a combination of these integrated component elements with modifications in the diffusion process and new layered metallization techniques. "On-Chip" protection structures that are more complex take up real-estate on the IC chip. Their size and complexity in part is a result of the need to comply to the changing industry requirements. TVS components are being designed today to meet the needs of newer and faster IC component circuits. Cost effective and space efficient, A TVS is able to divert the higher levels of transient currents and not interfere with circuit performance.

The predominant ESD standard during the 1980s was MIL-STD-1686, which was later included in MIL-STD-883. Today, ESD is defined in the International document IEC 1000-4-2 and the European equipment certificate document EN50082-2.¹ The IEC standard has been adopted by most countries as their test standard for Human Body Model (HBM) ESD. In addition, most IC component manufacturers have adopted the IEC standard for ESD withstand levels for IC component design and development. There are four threat sources when dealing with ESD: Human Body Model (HBM) being the most predominant, Machine Model (MM), Charged Device Model (CDM), and Field Induced Charged Device Model (FCDM) also known as Indirect ESD (IESD).²

Human Body Model ESD

The Human Body Model (HBM) also known as IEC 1000-4-2, is a significant threat to IC components during the handling and manufacturing process. All input pins, both power and data input/output ports, are required to be protected throughout this process. Protection circuit designs vary between power and I/O ports, but both input pins have to survive the perils of handling by individuals during manufacturing and test.

A common scenario within the manufacturing environment is the discharge of a HBM-ESD voltage between two IC component pins. If the peak voltage did

not punch through the MOS structure, the peak current of the pulse would cause a junction short.³ Electrical tests and failure analysis confirms the failed devices. This type of failure can occur either during the manufacturing process or during final electrical test. The net result was always the same, a lower yield and higher manufacturing costs. Designing protection networks into the IC chip has improved manufacturing yields.

HMB-ESD does not have a constant set of voltage, current and waveform characteristics. Variations in ESD parameters are at the mercy of their environment, manufacturing and test areas which in many cases are unknown. However, a protection network must be designed for a given set of environmental ESD test conditions such as, IEC 1000-4-2 industry standard.

ESD is characterized as a voltage event which can have several different current levels, depending upon the source resistance. Source resistances can vary from 1500 ohms down to 0 (zero) ohms, depending upon the source threat. Typically, the lowest source resistance scenario is the case in which an individual is holding a metal tool, such as a screwdriver. Variations in either the source resistance or the static voltage will produce a difference in the actual transient current. Voltage levels can range from 200 volts to 15 kilovolts. IC components have been known to fail even at the lowest static voltage, due to a low source resistance. Although these voltage levels represent an industry standard test condition, as indicated before, real world ESD voltages can reach levels up to 40 kilovolts. At these levels, the voltage, current, and waveform characteristics are more complex, making it more difficult to design "On-Chip" protection networks. To complicate matters even more, there are now additional ESD source threats to be considered.

Machine Model ESD

Another significant ESD source threat is the Machine Model (MM). This model has been associated with a charged piece of equipment (test handlers), or furniture that transfers its charge to the sensitive component/circuit by direct contact or radiated emission. MM-ESD characteristically has had a high current value and faster wave front due to a lower source resistance and charged capacitor. "On-Chip" protection is more difficult due to the higher transient currents requiring more complex structures. This in turn increases the cost of the IC component and more work is required by the IC manufacturers to provide an "On-Chip" protection network for this type of ESD model. Direct contact MM-ESD is being defined with specific characteristic parameters and can be more easily duplicated. However, higher currents still present some challenges for the IC manufacturer. The radiated emission MM-ESD is more difficult to characterize, with repeatability, and is left up to the circuit/system designer for solutions.

Charged Device Model ESD

A third source of ESD is the Charged Device Model (CDM) which is gaining increased awareness for "On-Chip" protection due to semiconductor handling equipment transferring a charge directly to the IC component. This occurs when the IC package becomes charged through some manufacturing process, usually by some automated manufacturing or test equipment handling process. CDM-ESD has a fast wave front and a higher transient current similar to the MM-ESD. Existing "On-Chip" protection networks are either not fast enough or cannot handle the higher transient currents. The CDM-ESD model will require some changes in the design of the protection network which will affect the real-estate on the IC chip.

¹ The IEC 1000-4-2 document pertains only to HBM-ESD. At the present time, there are no specifications regarding MM, CDM, and FCDM source threats within the IEC documents.

² Marduguan, Michel, "ESD Hardening of Plastic Housed Equipment", *EMC Test & Design*, July/August 1994.

³ Mahanpour, Mehrdad & Morgan, Ian, "The Correlation Between Latch-up Phenomenon and Other Failure Mechanisms", *Electrical Overstress/Electrostatic Discharge Symposium Proceedings*, 1995.

Test equipment manufacturers are aware of the automated handling problem and new equipment is already being developed for manufacturing. This does not eliminate concern for the Charged Device Model in the real world. A repair technician with a hand held tool can cause a similar ESD event. This is becoming more of a problem once the IC component is installed into a circuit/system at the equipment stage.

Field Induced Charged Device Model ESD

A fourth emerging ESD phenomena is the Field Induced Charged Device Model (FCDM), also known as Indirect ESD (IESD).⁴ Although not completely characterized, this ESD event is generated by an electrostatic field, which is created by the discharge of an ESD pulse. It is similar in nature to an EMI/RFI field which can induce a voltage and current onto a data or power line. The transient that is induced onto the line or PCB trace is conducted into the IC component. The length of the PCB trace will determine the level of voltage or current induced on the line. This again, is done through transmission theory analysis. Induced ESD effects are more PCB dependent and can only be characterized by circuit/system design engineers.

When comparing waveforms and current levels to other ESD events, the FCDM falls in-between the HBM and MM for time (pulse duration) and current levels. As stated above, FCDM is compared to the electromagnetic emissions (EMI/RFI) from a variety of sources. Therefore, FCDM-ESD from any source, is the most difficult to duplicate due to the vast number of electrostatic field possibilities. There may be some effect on IC components during manufacturing, but the greatest effect is on the performance of the IC component after it is assembled onto the printed circuit board.

The IEC 1000-4-2 standard does not represent all possible real world ESD threats for equipment/systems in the field. For example, real world ESD events can range up to 40 kilovolts, well beyond the 8 kilovolt requirement defined in IEC 1000-4-2 for contact discharge. The transient voltage and source impedance will dictate the level of transient current. Both voltage and current must be considered when protecting against ESD events. Because real world (field) conditions are not always the same, actual ESD threat parameters will also vary. Additional field source threats, such as switching transient, tertiary lightning, conducted EMI/RFI and hot plug-in events, can also appear at the interface pins of an I/O port for line drivers/receivers. Most of these transient events are difficult to characterize at the IC component. Although voltage is one transient parameter most easily measured, it is the peak current and the waveform (duration) that is important for characterization. The current and waveform (duration) is also critical for the design of an "On-Chip" protection networks for IC components.

Radiated Emissions

Radiated emissions can affect the whole chip circuit and may require some shielding for protection. Protection networks and discrete components cannot effectively address this type of threat unless transient currents are conducted into the IC component through the I/O port. Protection against this type of transient event is generally the responsibility of the circuit/system designer at the board level. At the board level, characterization of the threat is by transmission line theory. In many cases, a trace on a printed circuit board (PCB) or a line connecting the PCB must be treated as an equivalent transmission line. Here, coordination of both the data line and power bus terminals is also important. Transients can be conducted into the IC component through both input terminals.

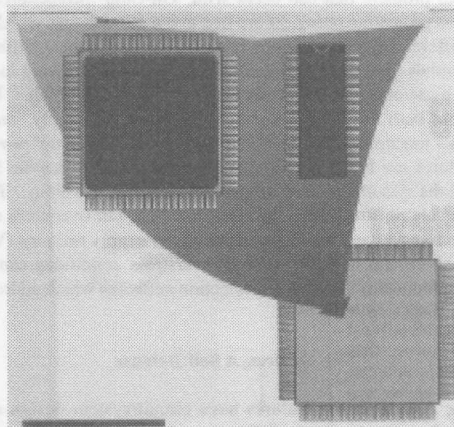
"On-Chip" Protection, A Self-Defense

IEC 1000-4-2 for HBM-ESD has been and is still the major threat environment for "On-Chip" protection network designs. However, the relationship between the ESD industry standard and the manufacturing environment has not been well correlated. Still, for no apparent reason, CMOS, NMOS, BiCMOS, etc. IC components have failed during handling either on the manufacturing floor or while being tested at a customer's facility. Failure analysis of several IC components, revealed that semiconductor junctions had a failure signature of

remelted silicon or a punch through in the MOS oxide structure due to some type of overstress. Although, some of these failures appear to be the result of high current conditions, the trigger mechanism was attributed to some type of voltage transient event, such as an undefined ESD pulse.

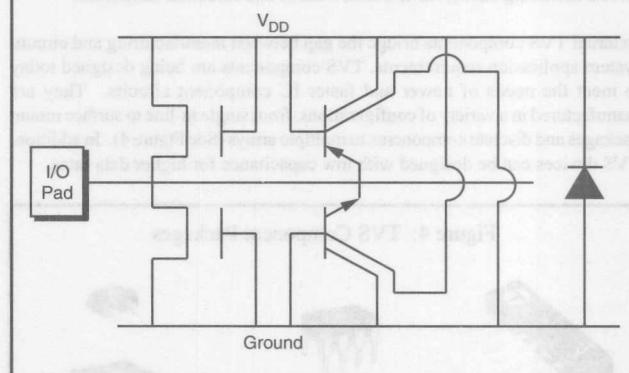
For some unknown reason, field failures still exist. The quest for additional ESD protection has reached into the very heart of the semiconductor chip's real-estate with "On-Chip" protection. As the number of I/O ports increases with functionality, the total Chip size will increase (See Figure 2).

Figure 2: Multiple function circuits means increased I/O ports requiring external TVS components.



The size and complexity of the protection network are also increasing to deal with higher transient currents and the speed of response of the incident pulse. Appearing as complex structures on the I/O input terminals, protection networks are at the mercy of their size (multiple element junctions), performance effectiveness (speed and noise or crosstalk), and transient event withstand levels (transient currents and voltages) (See Figure 3).

Figure 3: Double-diode Protection Circuit



Advances in IC technology from a 9 micron process chip structure to 0.8 micron or even 0.1 submicron topology, has created an even greater awareness for the need of higher levels of protection during manufacturing and test. As the IC component geometry is scaled down, susceptibility to an ESD event has become more critical. New and more complex "On-Chip" protection networks are being considered. These also have some limitations with respect to design, capability and reliability. These too, can interfere with circuit performance (crosstalk), functionality (signal loss) and increased size of the IC chip.

Complex vertical and lateral "On-Chip" structures contribute to leakage currents and create noise interference within the IC chip. Transient currents add to this

⁴ Pierce, Donald G., "Electrostatic Discharge (ESD) Failure Mechanisms", ESD Association 1995 ESD Tutorial, September 10-11, 1995, Phoenix Civic Plaza, Phoenix, Arizona.

overall design problem. Protection network structures are required to divert transient currents back through a common return terminal. All undesirable currents require a low impedance return path back to a point of entry which further complicates the protection network design and their location on the chip. A low impedance current path must also limit any disturbances that can affect the performance of the IC circuit. This can complicate the "On-Chip" protection design, requiring additional network elements. A better solution would be the separation of the protection circuit (network) from the IC component. A discrete transient voltage suppressor (TVS) component which can divert a higher level of transient current and not interfere with circuit performance, is recommended.

An additional problem that can occur with "On-Chip" protection is ground bounce. Most protection networks are tied to the rail voltages which can be a source of differential voltages on a common ground plane. Differences in ground potentials give rise to ground currents. Current flowing in a ground loop caused by a voltage difference can create additional problems. Excessive currents, from both the transient event and the power supply, can cause a semiconductor junction within the IC chip to fail short. "On-Chip" power supply clamp structures are being required to be more robust to handle follow on current once the circuit has been triggered by a transient voltage. Protection networks and clamp structures must absorb the ESD or overstress energy by diverting the transient current through the power supply rail pins (V_{CC} , V_{DD} or V_{SS}). Positive and negative voltage overstress conditions can result in additional problems for "On-Chip" protection networks which addresses only one of the voltage transients.

TVS Devices, A Self Defense

ESD field and certification failures have circuit/system design engineers considering IC protection at the circuit board level. In many applications, circuit boards are being retrofitted with external TVS components. Seasoned design engineers are adding TVS components at the board layout and system design stage to regain control of the transient threats from the real world EMI/EMC environments.

"On-Chip" protection is currently addressing the manufacturing environment. However, their ability to protect IC components at the board or system level from all ESD sources as well as other types of transients is limited. TVS components are designed to provide protection against most types of transient threats including HBM, MM, CDM, FCDM and Radiated Emissions.

External TVS components bridge the gap between manufacturing and circuit/system application requirements. TVS components are being designed today to meet the needs of newer and faster IC component circuits. They are manufactured in a variety of configurations, from single in-line to surface mount packages and discrete components to multiple arrays (See Figure 4). In addition, TVS devices can be designed with low capacitance for higher data rates.

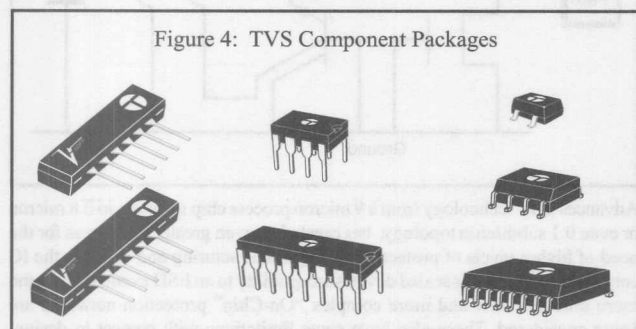


Figure 4: TVS Component Packages

Arrays are manufactured with discrete chips or monolithic structures, from 4 to 15 devices per package depending upon the package. TVS components are not only designed to meet the new industry standard immunity requirements, such as IEC 1000-4-2, but are designed to provide the best circuit performance for both medium and high data rate applications. Low capacitance devices are designed to maintain a constant capacitance value over the circuit operating voltage range. This insures a constant impedance at high data rates to allow

for impedance matching reducing signal reflections. Design engineers are becoming more aware of these TVS device characteristics and their relationship to the transient threat conditions for improved circuit withstand levels and performance.

External TVS components have an added advantage in that transient current loops are kept to a minimum. The location of TVS components on a PCB becomes very important. In addition to line impedance, a low impedance ground is obtained by locating a TVS component at the card edge of the PCB. A low impedance return path can also be obtained through a ground plane or an extra wide trace on the board. The return path must be capable of conducting the transient current back to a point of entry without substantially introducing a ground voltage potential difference.

ESD is considered a common mode event (similar to lightning), therefore, a common point of entry would be the ground plane or system chassis. Protection is from line to a common point, usually a ground plane, chassis, or signal return. A TVS component is located between each input line (I/O port) and the common ground point for common mode protection. Transients can be either differential or common mode. Switching transients are usually differential mode events. If differential mode protection is required, a TVS component is located between the two lines where switching transients can occur. It is important to remember that a return path for an ESD pulse is through the ground return path, whereas a switching transient is through a return line. In some applications, the return line path is the ground path.

From this information, it can be understood how and where to locate TVS components on a PCB for maximum IC protection. "On-Chip" protection networks do not allow this degree of freedom for both common mode and differential mode protection. External TVS components can minimize the transient current loop and isolate the sensitive IC component from the real world threats. These devices are designed to limit voltages, divert transient currents, and eliminate problems before they contaminate the sensitive IC chip at the PCB level. They can no longer be considered "just a bandage," but need to be a part of the initial circuit board design. Their design and configuration is important to the overall system/circuit performance in addition to protection against the many types of ESD threats.

Summary

Most "On-Chip" protection networks have been designed for lower levels of HBM-ESD voltages (8 kV or less). The upper transient immunity level is a product of some well-known industry standards, such as IEC 1000-4-2, MIL-STD-1686, ANSI S5.1/S5.2, and EN 50082-1. However, for many applications, these currently do not represent real world environments, nor the variety of threat conditions that IC components can be exposed to once assembled into equipment or on circuit boards. IC components, with "On-Chip" protection networks, are failing in the field due to some unknown ESD or industry environmental condition.

IC components with "On-Chip" protection have a level of transient immunity. They cannot be expected to perform their designed function under all types of ESD events and absorb ESD energy, without some contamination of the chip structure. As the ESD voltage increases and the transient current becomes larger, protection networks become larger. Increasing the "On-Chip" structure for additional types of ESD events and other potential source threats will add cost to the IC component and take up valuable real-estate on the chip. As the IC component packages become larger, with multiple terminals performing additional functions (computer on a chip), the number of pins to be protected will also increase. Performance can be compromised at the expense of the protection networks.

External discrete TVS components are the answer for protection from all real world transient threats at the board level. They divert the high transient currents and clamp the voltage to within a safe limit for the sensitive IC component. Newer TVS devices (discrete or array components) are designed for higher data rates without compromising circuit performance. In the future, external TVS components must become an integral part of the circuit design rather than an add-on product as a result of system certification or circuit failures.

AJTVS - The Forgotten Component In Circuit Design

by

David W. Hutchins

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In the past, electromagnetic compatibility (EMC) requirements for electronic equipment were relatively straightforward. Once a circuit design was completed, the next step was to lay out a printed circuit board (PCB) that provided the lowest level of radiated emissions for networked systems. FCC Part 15 Regulatory Standards are very explicit for electronic equipment and computer systems to be sold within the United States. Adherence to voltage sources and ground loops at the layout stages, along with proper decoupling networks and filters, helped minimize electromagnetic emissions and improved the overall performance of the circuit.

With the increased usage of more sensitive components in smaller areas, greater demands are being placed on I/O circuits to withstand lower externally conducted energy levels, as well as to minimize the internal influences on circuit performance. Due to the negative influence of noise on I/O cables and system performance, design engineers are now addressing input protection during the initial circuit design stages.

In the past, avalanche junction transient voltage suppression (AJTVS) devices were often used only on the supply voltage line to prevent transient interference to the sensitive integrated circuit. Transient voltage protection for data lines in a self-contained, closed loop system was not as important. With the usage of local- and large-area-networks (LAN), the threat to the data lines has increased to a level similar to that of power lines. Protection against transient overvoltages on the I/O ports has become important for distributed system networks. This concern includes the coordination of both power and data line protection elements.

Transient overvoltages are facts of life on power lines and have been well documented in various industrial standards such as ANSI/IEEE C62.41 and C63.90.1, UL 1449 and 497B, CSA 22.2. TR/40, etc. It was not until recently that these same types of transients were found to be present on external and internal distributed I/O cables. Transients from the same type of sources can appear on both the power and data lines. These transients can be generated both internally (motors, inductive switching, ESD, etc.) and externally (lightning, load switching, power cross, etc.)

It has only been within the past few years that the industry has recognized the possibility of data line transients as a problem. IEEE and IEC are currently working on draft documents (ANSI/IEEE C62.47 & IEC 1000-4-5) and on released documents (IEC 1000-4-2 & -4) to identify such transient sources as Electrostatic Discharge (ESD), Electrical Fast Transients (EFT), and lightning/switching threats that are applied to networked data lines as well as power lines.

Power and data line transients are identified by their voltage or current amplitudes and pulse waveforms. The amplitude is divided into an open circuit voltage or a short circuit current. The waveform is characterized by two distant pulses, an impulse (decaying exponential) and a ringwave (damped sinusoidal). This impulse is characteristic of an ESD, Switching, or lightning event. It has a rise time and decay time as shown in Figure 1 and Figure 2.

Lightning impulses are generally characterized as a combination wave: one

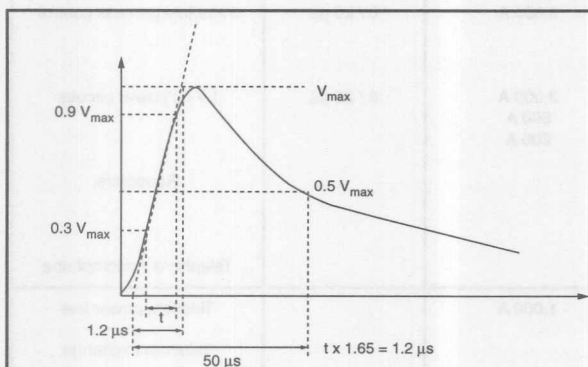


Figure 1: Open Circuit Voltage Impulse Waveform

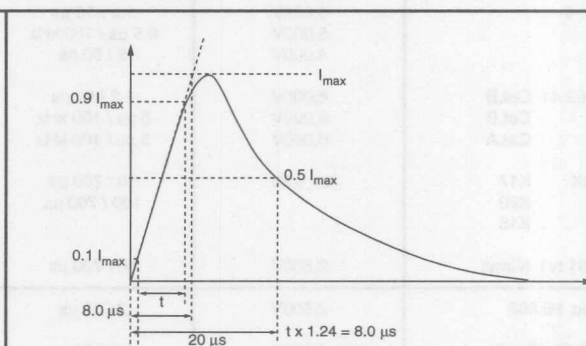


Figure 3: Open Circuit Voltage Ringwave Waveform

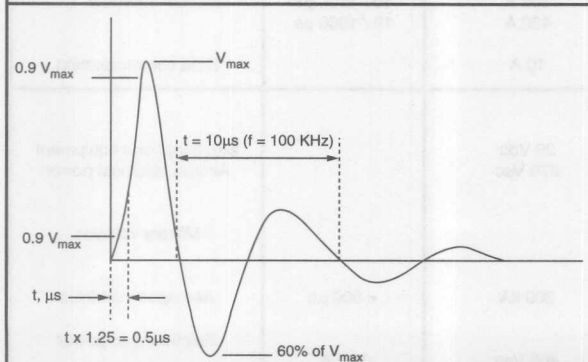


Figure 2: Short Circuit Current Impulse Waveform

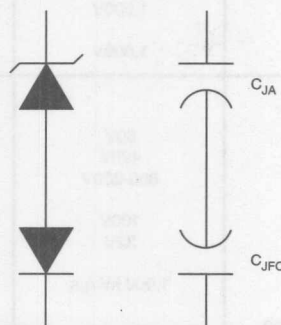


Figure 4: Compensating Diode & AJTVS Combination (Low Capacitance Device)

for voltage and another for the current. This voltage waveform is defined by a 1.2/50 μ s impulse, whereas the current waveform is defined by an 8/20 μ s impulse. The typical ringwave is characterized by a damped signal that is reflected on a line due to an imbalanced load condition (See Figure 3). The rise time is similar to the impulse waveform, whereas the ringwave is characteristic of the reflected load impedance. These two waveforms are being used to identify most of the industry standard transients as they may apply to specific applications (See Table 1).

Device Selection

From these characteristic transient parameters (amplitude and waveform), an appropriate AJTVS can be selected. It is the transient current handling capability of the AJTVS that is equated to the current amplitude of the transient. The peak pulse current (I_{pp}) rating of the AJTVS should be equal to or greater than the current of the transient threat for a given pulse duration. In this case, the pulse duration is the decay time defined as 50% of the peak amplitude, 20 or 50 μ s for the above impulse waveforms. This, however, is considered the second step in device selection for an AJTVS protector.

The first step is the identification of the appropriate AJTVS device stand-off voltage (V_{WM}) which should be greater than or equal to the line (operating) voltage of the circuit. Once this selection has been made, the peak pulse current selection can be made for the desired device type. A the following is a simple

comparison of the device parameters to circuit conditions:

1. Stand-Off Voltage (V_{WM}) > Operating Voltage (V_{OP})
2. Peak Pulse Current (I_{pp}) > Transient Current (I_T)
3. Clamping Voltage (V_C) < Voltage Protection

The clamping voltage is compared to the withstand voltage level of the sensitive component for the same pulse waveform.

This initial AJTVS selection process is appropriate for those transient application requirements on the power supply (V_{CC}) lines. For data I/O port protection, device selection requires an additional device selection parameter. This parameter is the capacitance of the AJTVS at a specified frequency. AJTVS capacitance is important due to the high speed data rates and length of data transmission. Too much capacitance will attenuate the signal. In contrast, too low a capacitance will lower the level of transient current handling capability of the protection element.

Device capacitance is proportionate to the current handling capability of the AJTVS. The lower the current rating the lower the capacitance. For an AJTVS device to handle high transient currents, the device is designed with a large

Table 1: Industry Simulated Transient Threats

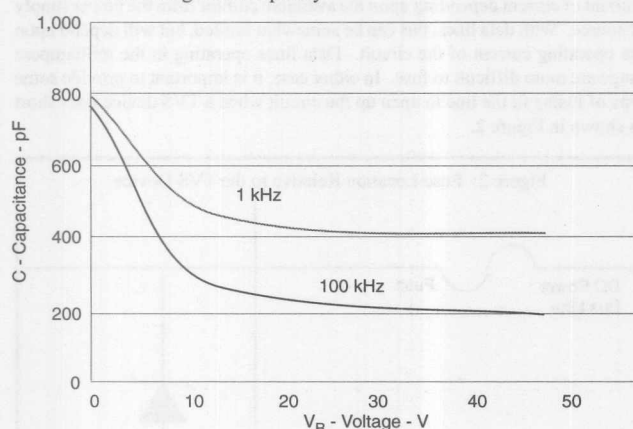
STANDARD	VOLTAGE	WAVEFORM	CURRENT	WAVEFORM	APPLICATION
IEEE-472	4,500V	10/1000 μ s	17 A		Protective relays
ANSI C37 90.1	2,500V	1.25 MHz/ 6 μ s			Static relays (SWC)
IEC TC 102 D	6,000V	1.2 / 50 μ s			Remote-control receivers
IEC 255	5,000V	1.2 / 50 μ s	12 A		Static relays
IEC TC 41	1, 2.5 kV	1 MHz	25 A		Static relays
IEC 801-4	5,000V 5,000V 4,000V	1.2 / 50 μ s 0.5 μ s / 100 kHz 5 / 50 ns	3,000 A	8 / 20 μ s	Industrial process control
ANSI C62.41 Cat.B Cat.B Cat.A	6,000V 6,000V 6,000V	1.2 / 50 μ s 5 μ s / 100 kHz 5 μ s / 100 kHz	3,000 A 500 A 200 A	8 / 20 μ s	LV ac power circuits
CCITT IX K17 K20 K15	3 - 5 kV	10 / 700 μ s 100 / 700 μ s			Repeaters
FTZ 4391 tv1 (Gmy)	2,500V	10 / 700 μ s			Telephone / microphone
FCC Sec. 86.302	2,500V	2 / 10 μ s	1,000 A		Telecom power line
PTT 692.01 (Swiss)	4,000V	1.0 / 50 μ s			Telecom exchange
EIA PM-1361	2,500V 1,000V 1,500V	2 / 10 μ s 10 / 1000 μ s 10 / 1000 μ s	1,000 A 200 A 400 A	2 / 10 μ s 10 / 1000 μ s 10 / 1000 μ s	Telecom terminals DP interface
UL-4978	1,000V	10 / 1000 μ s	10 A		Data communication
UL-1459					
MIL-STD.704A	50V 425V 600-200V	45 ns 30 ns 10 - 50 μ s	29 Vdc 270 Vac		Std. telephone equipment Aircraft electrical power
MIL-STD704D MILSTD-1275	100V 32V	50 ns 200 ns			Military vehicles
MIL-STD1757	1,000 kV / μ s	1.2 / 50 μ s	200 kA	< 500 μ s	Aerospace vehicles
DOD STD-1399, Sec.300 440V 115V	2,500V 1,000V	1.2 / 50 μ s 1.2 / 50 μ s	400 Vac 115 Vac	500 A 200 A	Shipboard ac power

cross sectional area avalanche junction. The large junction area for a given voltage device results in a large device capacitance. To compensate for the large capacitance, a compensating diode is used in series with the AJTVS device. A circuit schematic of the series combination of diodes is shown in Figure 4.

The AJTVS device capacitance will decrease with increasing bias voltage and frequency (See Figure 5). The compensating junction diode will increase with an increase in bias voltage due to the forward conduction of the diode. Although the compensating diode has the lowest individual capacitance of the two devices, the change in capacitance with bias voltage is about the same, resulting in little change in the series combination. Most device specifications will provide the combined capacitance at 0 volts and a frequency of 1 MHz. Generally, this is the highest value of capacitance for the two diodes. Deviations in the values at higher voltages can occur if the individual diode devices are not properly selected or specified.

To determine the combined diode device performance in a specific circuit application, it is recommended that an in-circuit test be performed at the operating frequency or data rate. A transient voltage test should also be

Figure 5: The AJTVS Device Capacitance will decrease with increasing bias voltage and frequency.



performed to assure the correct device selection in reference to its location in the circuit. The in-circuit testing should include a simulation of the transmission distance to assure minimum signal attenuation.

High speed data lines can often become contaminated by high speed glitches. Locating the low capacitance AJTVS at the PCB card interface (inside the equipment) is recommended to reduce circuit switching and ESD transient threats. At this location, a lower peak pulse power device may be used as a result of the increased line impedance to help reduce the actual transient current delivered to the AJTVS device. A surface mount device is recommended at the PCB interface location because it has the lowest lead inductance, reducing any overshoot voltage due to fast rise time transients. Both the trace paths and device lead lengths add to the overshoot voltage during a fast transient event such as ESD and EFT. With the reduction in the lead length to the AJTVS device, a lower clamping voltage is realized that is more representative of the protection voltage afforded by the AJTVS.

AJTVS devices are designed to provide the lowest clamping voltage level at the highest peak pulse current rating. For this reason, protection devices are designed into a system as independent components. They can clamp the voltage to a desired level and divert the peak transient currents away from the sensitive component. They are available in discrete form or in multiple chip arrays for better placement on the PCB and maximum circuit and device performance. Individual low capacitance AJTVS devices are more easily placed on the PCB for good EMC coordination and overall circuit performance. These devices are recommended for placement at the PCB interface to prevent the high transient currents from entering the boards and contaminating the ground planes. To prevent board contamination, it is important to design in these protection devices and apply good impedance control in the ground return path.

Summary

The addition of components is never a substitute for good engineering practices. However, for total electromagnetic compatibility, circuit performance, and system reliability, a transient voltage suppressor (TVS) is generally a wise investment. These types of components must be designed in at the initial design stages to prevent compromises later on when the system crashes or components are damaged. A more cost effective and reliable solution can be realized with the addition of a low capacitance AJTVS data line protector at the initial schematic design and layout stages.

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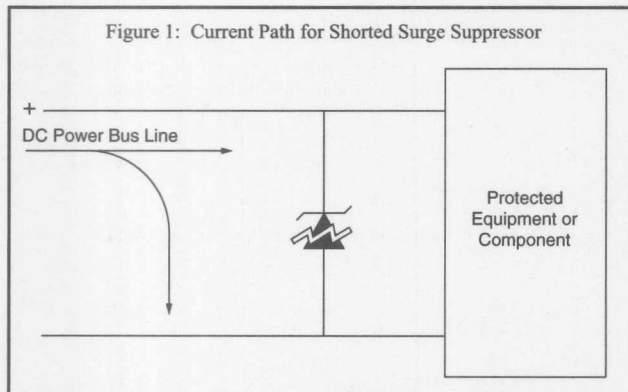
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Transient voltage suppressors (TVS) will fail if they are subjected to conditions beyond their designed limits. Therefore, it is important to understand the types of failure modes associated with TVS devices before designing them into a circuit application. There are three basic types of failure modes:

1. Shorted devices conduct current away from the circuit or system affecting its performance.
2. Open devices are transparent to the circuit/system and will not usually distribute circuit functions. In either case, it is difficult to determine if the TVS device is still functioning while in the circuit.
3. Degraded devices are most difficult to detect in the circuit. These can be devices with high leakage currents which may not adversely affect circuit performance, except under elevated operating temperatures.

With the thought that a TVS device can fail, there are some additional terms that designers would like to impose on the protector to ease this problem. One such term is a "Fail Safe" condition. The term "Fail Safe" implies some level of safety which cannot be used in connection with a TVS device. Due to the very nature of the unknown transient threat, there are no 100% guarantees. "Fail Safe" is one of the most misunderstood terms regarding transient protection. It is important to define the term and discuss why it should not be used in reference to a TVS device.

Words have different meanings to different people which is the case with the term "Fail Safe". A TVS device cannot assure a fail safe environment. Unfortunately, a TVS device will fail when subjected to a transient beyond its designed capability. If the circuit or system is not properly fused, a shorted TVS device can become a safety hazard conducting operating currents through the return path. Even with the proper design-in and adherence to good engineering practices, this term should not be used in describing the function of the protection network. Quite often, the unknown transient threat, along with some of the guesswork regarding the sizing (Peak Pulse Power Rating) of the TVS device, will suggest some level of risk in the overall protection system. The risk, in this case, is the trial and error method used to guarantee proper TVS device selection versus in terms of its location. This type of selection process may take some time to accomplish when the transient threat cannot be fully defined. "Fail Safe" may be used in conjunction with a complete systems approach, but not with a component such as a TVS device.

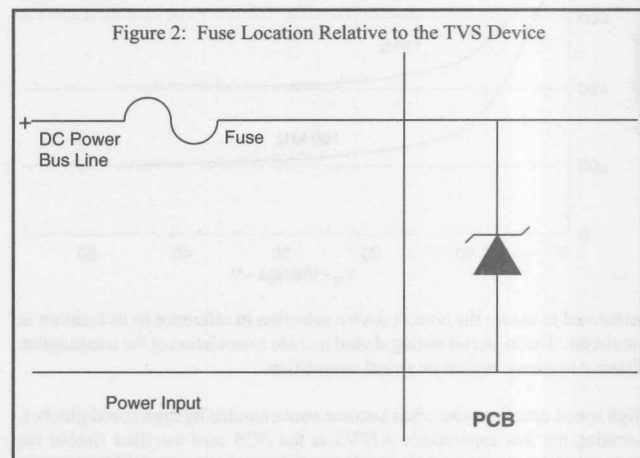


FAILURE MODES

Shorted TVS Devices

In most applications, the preferred method of failure is a short. A short is defined when the TVS device has a resistance value of less than 1 ohm at a dc voltage of 0.1 volts (ref. IEEE/ANSI C62.35). In the more practical world, a shorted device will start to conduct a significant amount of operating current to ground as seen in Figure 1.

The actual current shunted to ground will depend upon the resistance in the line ahead of the TVS device. For the power line, this could mean a significant amount of current depending upon the available current from the power supply or source. With data lines, this can be somewhat limited, but will depend upon the operating current of the circuit. Data lines operating in the milliamperage range are more difficult to fuse. In either case, it is important to provide some type of fusing in the line to open up the circuit when a TVS device does short as shown in Figure 2.



The fusing element must take into consideration two possibilities. First, does it have the ability to handle the required transient current without interrupting the circuit functions. Second, is it able to open the line when the TVS device does short.

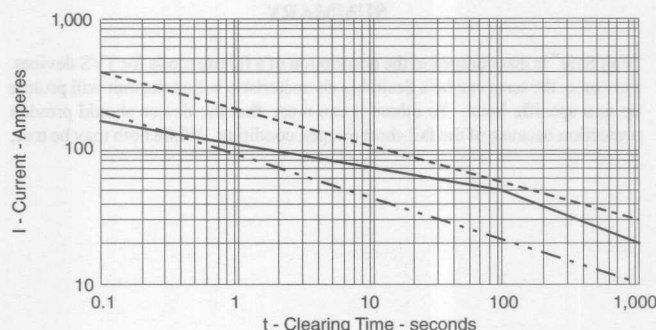
Open TVS Devices

An open TVS device is defined as a diode that has a breakdown voltage $V_{(BR)}$ greater than 150% of the pretested value at an applied test current (I_p) (ref. IEEE/ANSI C62.35). For this test, the unit must be taken out of the circuit for verification. An open device in the circuit will not exhibit any of the standard electrical characteristics such as leakage current or clamping voltage. Once out of the circuit, the TVS device can be tested on a curve tracer for verification of the open condition.

In an improperly fused circuit, a device that has been shorted can become open after an applied operating current is allowed to conduct through the device for a period of time. Figure 3 shows the fusing currents and time durations for

each of the major axial lead type package. When this occurs, there is usually some visible evidence in the form of a burn mark on or within the device, indicating an open unit.

Figure 3: Clearing Time for Transzorb® TVS Devices (SA, 1.5K & 1.5KE)
Fail Open Circuit



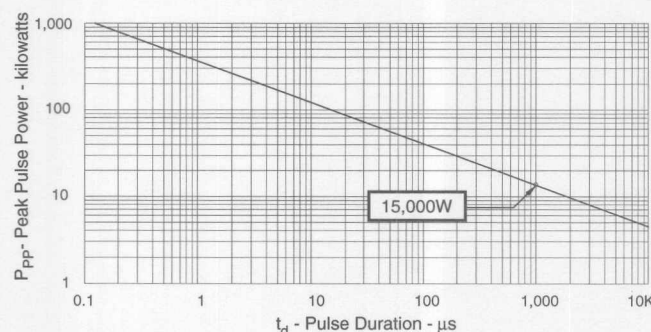
Degraded TVS Devices

Devices that degrade are more difficult to detect. These types of failed devices will exhibit an increase in the reverse leakage current under normal operating voltages (equivalent to the stand-off voltage). According to IEEE/ANSI C62.35, a degraded failure mode has occurred when the avalanche junction surge suppressor has a stand-by current greater than the maximum specified. On the power bus line, this level of current may not be noticed until the leakage current reaches the upper limit of the power supply current, or when the unit shorts from the increased current conduction. For data lines, this value may be much less due to the fact that there can be loss of data transmission of information. A device will act as a low impedance shunt path to ground.

TRIAL & ERROR

The transient threat and the location of the transient voltage suppressor in the equipment will also have a major influence on the type of failure mode. In some applications, the transient currents and impulse waveform cannot be completely defined. As a result, the correct TVS device may not be designed in. In this case, the TVS device application is a trial and error method. A TVS device is designed to withstand a specific level (power) of transient threat as defined by a peak pulse power rating versus pulse width curve as shown in Figure 4.

Figure 4: Peak Pulse Power vs Pulse Time



Most manufacturers will provide a peak pulse power versus time curve on their individual product data sheets. This will provide the designer with the maximum power limit within a product family or series of devices. It is up to the circuit or system designer to translate this product information into the appropriate threat level. Threat levels should always be defined in terms of the peak current, amplitude, and impulse waveform rather than to calculate

the energy of the TVS device from the power curve. Energy is not a key parameter. Energy contained within the transient event is not the energy deposited in the TVS device. Equating the transient current threat to the peak pulse current rating of the TVS will ensure proper device selection and the continuous operation of the protector in the application. However, there are those applications in which the actual transient current cannot be defined. At best, the identification of the source of the threat is necessary; that is, lightning, switching, ESD or NEMP. From this information, the manufacturer can provide the direction for initial product selection.

Product selection begins as follows:

1. Stand-Off Voltage > Operating Voltage
2. Peak Pulse Current > Transient Current
3. Clamping Voltage < Voltage Protection

It is necessary to equate the transient current to the peak pulse current of the TVS device. The transient current must always be less than the peak pulse current of the TVS for continuous operation. Remember, it is the transient current that will cause the TVS device to fail in a shorted mode.

Device shorts can occur at the semiconductor chip junction surface interface or within the bulk material. This type of short will appear as a burn spot on the junction surface or as a dark spot on the top/bottom of the silicon chip. The bulk type of device short will be a function of the amount of transient current that was passed through the silicon chip. The burn spot can be as small as a pin hole in the die and as large as a funnel hole of a few millimeters in diameter. In both cases there is evidence of remelted semiconductor material. Its size will usually depend upon the current amplitude of the transient and any additional follow-on current that is present over a short period of time. Longer pulses will usually remelt the solder material which can bridge the silicon chip causing the shorted condition. In this case, removing the solder bridge will allow the TVS device to recover and appear as a good device.

Fusing

Follow-on current after a TVS device has failed short can become a safety or circuit performance problem. For these reasons, it is suggested that a fuse or fusible link be inserted in the line ahead of the TVS device on both the power and data line applications. Selection as well as location of a fusing element is important. As shown in Figure 3, it is possible to determine the I^2t value necessary to select the fuse for any follow-on current. As this data is defined as the clearing time for a TVS device to open up for a continuous applied current, it is necessary to select a fuse with an I^2t characteristic below the device capability. Location of the fuse is best closest to the TVS device in the series line for board level protection (See Figure 2). For equipment and high level systems protection, the fusing element can be a circuit breaker located at the point of power entry. At this location, the power and transient currents are terminated at the point of power entry input to the equipment preventing any additional problems such as safety hazard, data errors, or component damage.

One of the most difficult problems is the identification and, sometimes, location of the failure. In-line tests are often used as the checkout procedure for the system/circuit's performance. With a transient voltage suppressor, this may not be the best solution.

1. The first step is the identification of problem area; that is, power bus or dataline.
2. The second step is to perform a visual inspection to locate the failed device or see evidence of a burn spot on a component.
3. The third step is to apply power to the circuit for performance testing and test for any loss of data.

If there are any major problems, tripping of a circuit breaker (CB) or a blown fuse will indicate some type of line problem. Trace the line to the problem

SECTION 9

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9-9	Pin and Pad Dimensions

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PRODUCT PACKAGING INFORMATION

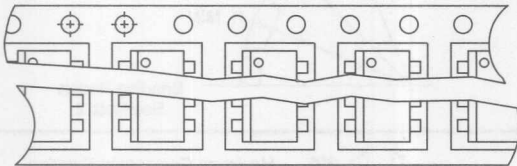
Surface Mount

MINIMUM PACKAGING QUANTITY

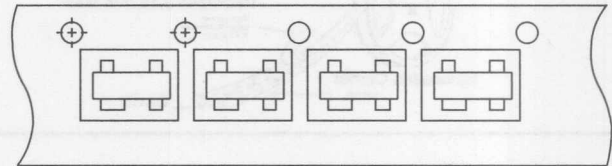
BODY	MANUFACTURES LOGO	AVAILABLE PACKAGING Tape & Reel	
		7" Qty.	13" Qty.
SMDJ	ProTek Devices	—	3K
SOIC-8	ProTek Devices	1K	2.5K
SOIC-14	ProTek Devices	1K	2.5K
SOIC-16	ProTek Devices	1K	2.5K
SOIC-16L	ProTek Devices	1K	2.5K
SOIC-20L	ProTek Devices	—	1K
SOT-23	ProTek Devices	3K	10K
SOT-23-6	ProTek Devices	3K	10K
SOT-143	ProTek Devices	3K	10K

Note: Quantities listed above are for minimum packaging quantity only. For minimum order quantity, please consult the ProTek Devices Sales Department.

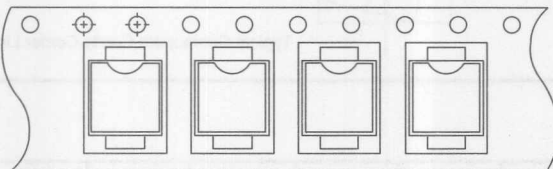
SO-8, SO-14, SO-16, SO-16L, SO-20L
(8 mm, 12 mm, 16 mm, 24 mm Tape)



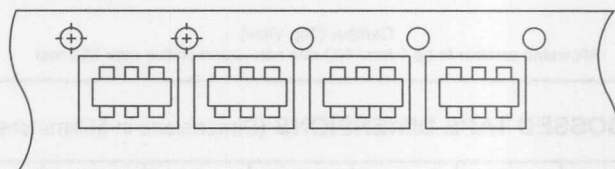
SOT-143
(8 mm Tape)



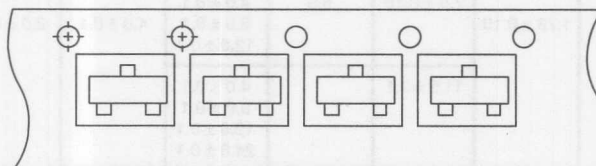
SMC
(16 mm Tape)



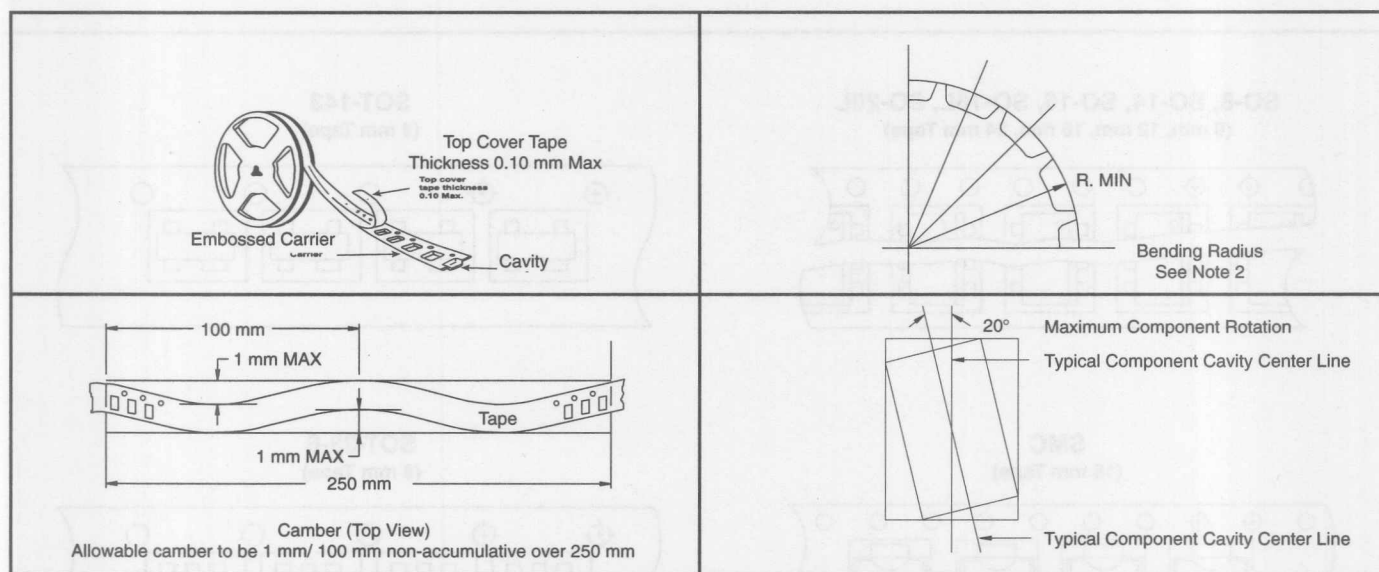
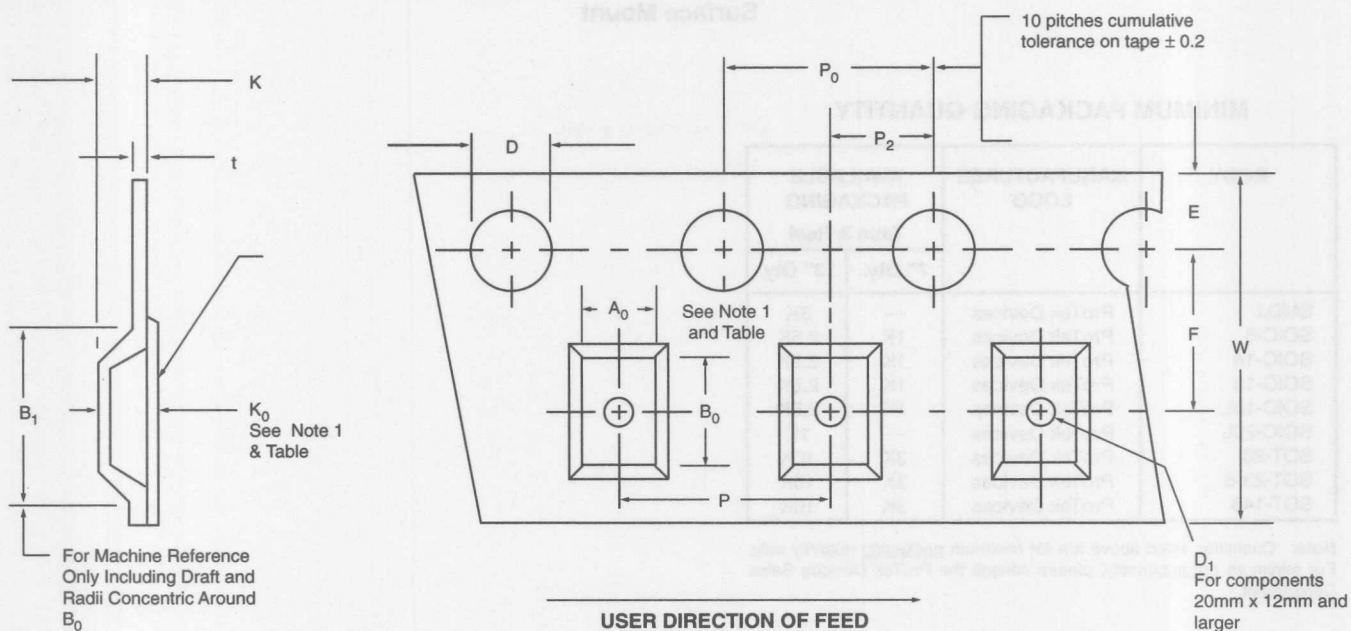
SOT-23-6
(8 mm Tape)



SOT-23
(8 mm Tape)



EMBOSED CARRIER TAPE SPECIFICATIONS



EMBOSED TAPE DIMENSIONS (Dimensions in Millimeters)

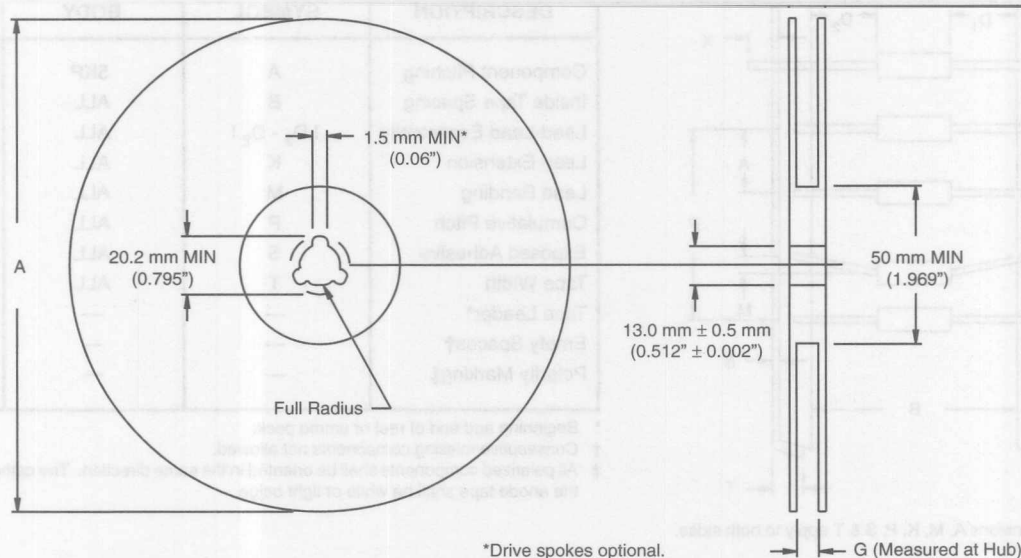
TAPE SIZE	B ₁ (MAX.)	D	D ₁ (MIN.)	E	F	K (MAX.)	P	P ₀	P ₂	R (MIN.)	T (MAX.)	W
8 MM	4.2	1.5 ± 0.1 -0.0	1.0	1.75 ± 0.10	3.5 ± 0.05	2.4	4.0 ± 0.1	4.0 ± 0.1	2.0 ± 0.05	25	0.4	8.3
12 MM	8.2		1.5		5.5 ± 0.05	4.5	4.0 ± 0.1 8.0 ± 0.1		2.0 ± 0.1	30		12 ± 0.3
16 MM	12.1				7.5 ± 0.10	6.5	4.0 ± 0.1 8.0 ± 0.1 12.0 ± 0.1			40		16 ± 0.3
24 MM	20.1				11.5 ± 0.1		4.0 ± 0.1 8.0 ± 0.1 12.0 ± 0.1 24.0 ± 0.1			50	24 ± 0.3	

Note 1: A_0 , B_0 , and K_0 are determined by components size. The clearance between the components and the cavity are per chart above. The components cannot rotate more than 20° within the determined cavity.

Note 2: Tape and components shall pass around radius "R", without damage.

Packed per EIA/JEDEC Standard RS-481

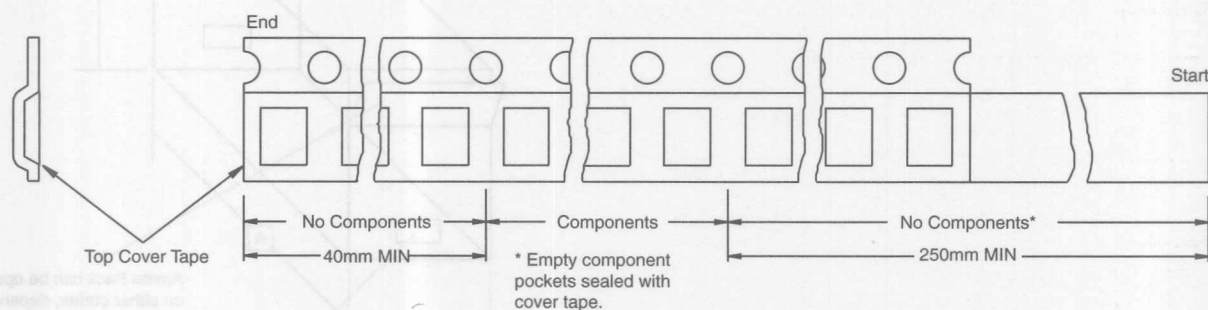




REEL DIMENSIONS (Dimensions in Millimeters)

TAPE SIZE	A MAX	G	T MAX
8 mm	330	8.4 + 1.5, -0.0	14.4
12 mm	330	12.4 + 2.0, -0.0	18.4
16 mm	330	16.4 + 2.0, -0.0	22.4
24 mm	330	24.4 + 2.0, -0.0	30.4

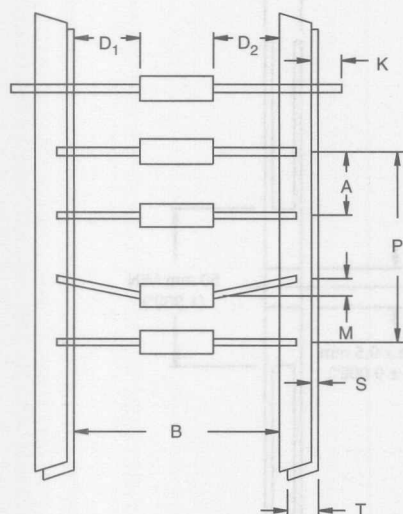
START & FINISH SPECIFICATIONS



USER DIRECTION OF FEED

Packed per EIA/JEDEC Standard RS-481

THROUGH-HOLE: AXIAL LEADED SPECIFICATIONS



Dimensions A, M, K, P, S & T apply to both sides.

REEL DIMENSIONS (Dimensions in Millimeters)

DESCRIPTION	SYMBOL	BODY	SPECIFICATION (mm)
Component Pitching	A	5KP	5.0 ± 0.5 , 10.0 ± 0.5
Inside Tape Spacing	B	ALL	52.4 ± 1.5
Lead-Lead Eccentricity	$ D_2 - D_2 $	ALL	1.4 MAX
Lead Extension	K	ALL	0.8 MAX
Lead Bending	M	ALL	1.2 MAX
Cumulative Pitch	P	ALL	2.0 Per 10 Pitch
Exposed Adhesive	S	ALL	0.8 MAX
Tape Width	T	ALL	6.0 ± 0.4
Tape Leader*	—	—	300.0 MIN
Empty Spaces†	—	—	< 0.1%
Polarity Marking‡	—	—	—

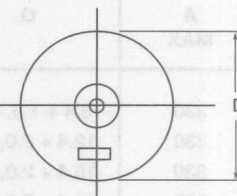
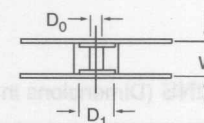
* Beginning and end of reel or ammo pack.

† Consecutive missing components not allowed.

‡ All polarized components shall be oriented in the same direction. The cathode tape shall be colored and the anode tape shall be white or light beige.

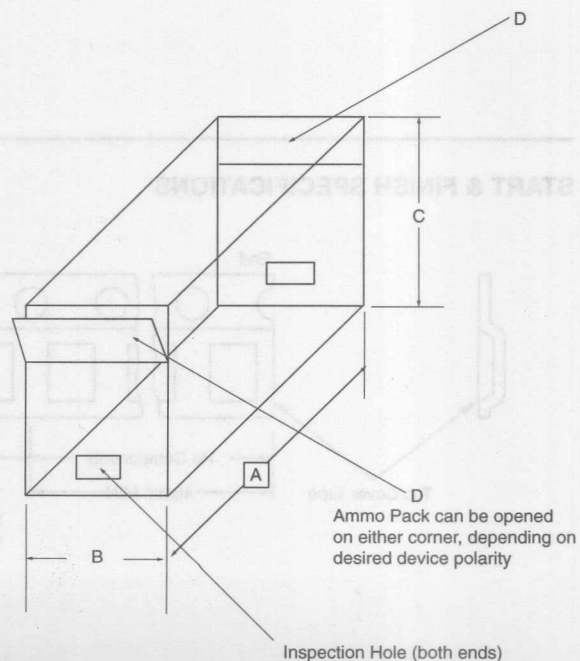
REEL DIMENSIONS

DESCRIPTION	SYMBOL	SPECIFICATION (mm)
Reel Diameter	D	330.0 TYP.
Core Diameter (O.D.)	D_1	85.7 ± 0.3
Arbor Hole Diameter	D_0	16.6 ± 0.4
Reel Width	W	79.0 ± 1.0



AMMO PACK DIMENSIONS

DESCRIPTION	SYMBOL	SPECIFICATION (mm)
Length	A	250.0
Width	B	75.0
Height	C	107.0
Ammo Pack Opening	D	—



Packed per EIA/JEDEC Standard RS-296

